Ref. Ares(2023)4102956 - 13/06/2023

IW-NET

Innovation-driven Collaborative European Inland Waterways Transport Network

D4.1: Specification of Application Scenarios, deployment of Digital infrastructure and LL coordination

Version: 0.9

Lead Beneficiary: INLE

Delivery Date: 31/05/2023

Dissemination Level: Public

Type: Report

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 861377.

Document Information

Title:	Innovation-driven Collaborative European Inland Waterways Transport Network
Acronym:	IW-NET
Call:	H2020-MG-2019-TwoStages
Type of Action:	RIA
Grant Number:	861377
Start date:	01 May 2020
Duration:	36 Months
URL	www.iw-net.eu

Deliverable

Title	D4.1: Specification of Application Scenarios, deployment of Digital infrastructure and LL coordination
Work Package	WP4 - IW-NET Living Lab
Dissemination Level	Public
Delivery Date	31/05/2023
Lead Beneficiary	INLE
Lead Authors	Zisis Palaskas (INLE)

Document History

Version	Date	Modifications	Contributors
0.1	1/6/2020	Extensive Archimate Models of all IW-NET and mapping to the Living Lab, Methodology Definition.	Zisis Palaskas (INLE)
0.2	1/9/2020	Input from the Application Scenarios, Link with Infrastructure Developments, analysis of Architecture.	Zisis Palaskas (INLE)
0.25	1/7/2021	First Deployment of Infrastructure and Trainings	Nikos Chalvatzis (ICCS)
0.4	15/12/2021	Update of LLs Progress	Peter Geirnaerd (OHB), Yves de Blic (MTL) Patrick Specht (ISL)
0.5	15/02/2022	AS summaries and Impacts analysis	Rik Arends and Richard van Liere (SFC)
0.65	15/12/2022	Second Deployment of Infrastructure and related updates	Nikos Chalvatzis (ICCS)
0.7	15/02/2022	Analysis and Mappings of the Application Scenarios	Zisis Palaskas (INLE)
0.85	15/02/2023	Updates of the Application Scenarios	Peter Geirnaerd (OHB), Yves de Blic (MTL) Patrick Specht (ISL)
0.9	31/05/2023	Integration of sections 1, 6, elaboration of section 2 and exec summary	Zisis Palaskas (INLE)

Executive Summary

The IW-NET D4.1 document, titled "Specification of Application Scenarios, deployment of Digital infrastructure and LL coordination," provides a comprehensive overview of the IW-NET project's application scenarios and their implementation methodologies, and a comprehensive and detailed roadmap for the implementation and evaluation of the IW-NET project's application scenarios, offering insights into the project's innovative strategies and methodologies, providing a clear framework for understanding the project's impacts and potential benefits.

The document presents three main application scenarios: AS1, AS2, and AS3, each further divided into two sub-scenarios. These scenarios represent the IW-NET approach to enhancing the efficiency, competitiveness, and sustainability of Inland Waterway Transport (IWT) services.

AS1 focuses on the application and testing of advanced digitalization technologies (AS1A) and the use of data-driven strategies to navigate uncertain water conditions (AS1B). AS2 aims to revolutionise collaborative IWT management and planning (AS2A) and optimize the use of shore power and berth planning (AS2B). AS3 explores the future of IWT, investigating the use of autonomous vessels for urban distribution (AS3A) and the advanced use of GALILEO services for navigation (AS3B).

Each application scenario has been mapped to the Modal Shift Enablers (MSEs) and Unique Value Points (UVPs) of the IW-NET project. This mapping provides a structured approach to understanding the project's impacts and outputs, offering a clear framework for evaluating the success of each scenario. The document also provides Key Performance Indicators (KPIs) and user stories for each scenario, offering a user-focused perspective on the project's objectives and potential benefits.

The IW-NET project employs an Agile methodology, for implementation. This approach ensures flexibility and adaptability, allowing for continuous improvement and refinement of the project's strategies. The Design Thinking approach is specifically applied to AS2, promoting innovative problem-solving and user-centered design. The document also establishes an analysis framework for the Living Lab, applying the innovations developed in WP1 and analysing all project components using the ArchiMate 3.2 framework. This framework allows for a thorough and systematic evaluation of the project's impacts and outputs.

The results collected from the application scenarios form the foundation for the verification and validation of the IW-NET solutions and will be used for driving capacity building initiatives and shaping the IWT roadmaps of WP5. These results are expected to provide valuable insights into the pathways towards the exploitation and commercialization of IW-NET solutions.

Disclaimer

List of Abbreviations

Abbreviation	Description
ABM	Agent-based Modelling
AIS	Automatic Identification System
API	Application Programming Interface
ARPA	Automatic Radar Plotting Aid
BMVI	Federal Ministry of Transport and Digital Infrastructure
CEF	Connecting Europe Facility
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
DES	Discrete Event Simulation
DMP	Data Management Plan
DSS	Decision Support System
FIFO	First-in-first-out
GA	Grant Agreement
GNC	Guidance, Navigation, and Control
GIS	Geospatial Information System
Github	Internet hosting service for software development and version control
GUI	Graphical User Interface
IAM	Identity and Access Management
IoT	Internet of Things
IWT	Inland Waterway Transport
KANBAN	Method for agile project management
KG	Knowledge Graph
KPI	Key Performance Indicator
LPWAN	Low Power Wide Area Network
LoRaWAN	Long Range Wide Area Network
LSP	Logistics Service Provider
ML	Machine Learning
PPP	Precise Point Positioning
REST	Representational State Transfer
RIS	River Information Services
ROI	Return on Investment
RTK	Real Time Kinematic
SCRUM	Framework to achieve adaptive solutions for complex problems
SOW	Spree-Oder Waterway
UI	User Interface
UX	User Experience
VM	Virtual machine
VTMS	Vessel Traffic Management System

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Context and Scope of D4.1

The deliverable D4.1 is the output of Task T4.1 that prepares the way, and monitors the three IW-NET Application Scenarios, which consequently are validating and testing the outputs of the innovation leading work-packages WP1 to WP3. The IW-NET Living Lab (see Figure 1) serves as the testbed for IW-NET solutions through a series of validating experiments conducted within the Application Scenarios within the three research and innovation areas: Digitalization Infrastructure Development (WP1), IWT Infrastructure Improvements (WP2) and Innovative Vessel Technologies and Services (WP3), which aim to assess the impact of digitalization, intelligent traffic management, and new technologies in inland waterway transport (IWT), including vessel automation for urban distribution.

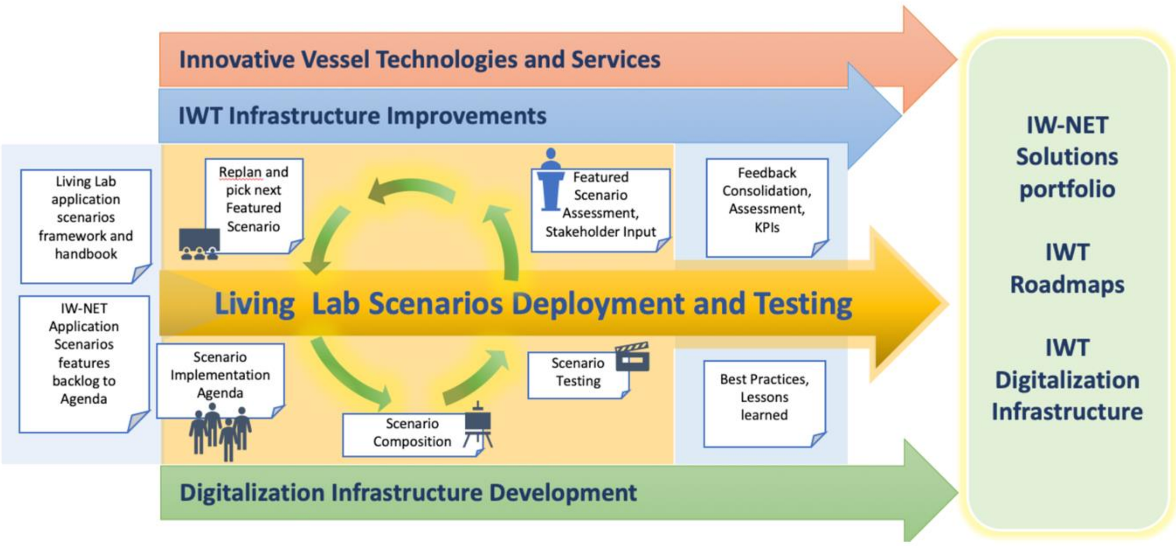

Figure 1: IW-NET Living Lab

A. The *Digitalisation Infrastructure Development* solutions are configured, deployed, and tested in Application Scenarios AS1A and AS1B. The aim is to transform and enhance IWT operations and improve sustainability via innovative technologies and solutions, encompassing several key aspects:

- *Data Integration and Exchange*: Enabling seamless data integration and exchange among different stakeholders and systems involved in IWT operations using the EPCIS GS1 standard and Blockchain. This involves establishing a digital infrastructure for information-sharing to facilitate real-time and secure data flows and to support Big Data Analytics.

- *IoT and Connectivity*: IW-NET leverages the Internet of Things (IoT) and connectivity solutions to enable real-time monitoring, tracking, and control of vessels, cargo, and infrastructure. IoT sensors and devices are utilized to collect data, which is then analysed to gain insights and optimize operations. This data is transformed and conform to GS1, used for hierarchical tracking and to support synchro-modal solutions.

- Advanced Analytics and Decision Support: Use big data analytics, Knowledge Graphs and machine learning, to analyse the collected data and provide decision support. This includes optimizing vessel routing, resource allocation, and traffic management to improve efficiency.

- Digital Services and Platforms: The IW-NET architecture is services oriented, digital services and platforms that provide value-added features and functionalities for stakeholders in the

IWT ecosystem. These services may include real-time tracking, synchro-modal operations, supply chain visibility, and collaborative planning tools.

B. The *IWT Infrastructure Improvements* are configured, deployed, and tested in Application Scenarios AS2A and AS2B. The aim is on improving inland waterway transport (IWT) infrastructure, also by introducing shore power solutions to enhance the sustainability and efficiency of IWT operations. Key challenges related to infrastructure maintenance, port operations, and environmental impact are addressed too. The infrastructure-related improvements within IW-NET include the following:

- *Infrastructure Maintenance:* Effective maintenance of IWT infrastructure, such as locks, waterways, and berths, developing strategies and tools for infrastructure asset management, to minimize disruptions to IWT operations.
- *Port Operations:* Optimise port operations by implementing solutions for efficient slot management, scheduling notifications, and support services for restricted drafts. By streamlining port operations, the pillar aims to reduce costs, improve reliability, and enhance the overall efficiency of IWT services.
- *Shore Power Solutions:* Introduce shore power solutions for IWT, providing vessels with electrical power while they are berthed at ports, eliminating the need for onboard generators. This reduces emissions and noise pollution in port areas, is environmentally friendly and contributes to sustainability.

C. The Innovative Vessel Technologies and Services are configured, deployed, and tested in Application Scenarios AS3A and AS3B. The aim is to introduce advanced solutions to optimize vessel operations, improve efficiency, and enhance the overall performance of the inland waterway transport (IWT) sector, addressing several key aspects related to IWT vessels:

- *Automation and Autonomous Vessels*: IW-NET explores the use of automation technologies and autonomous vessels in IWT operations. This involves exploring new vessel types and configurations that maximize efficiency, reduce emissions, and enhance navigability, by developing innovative vessel designs with eco-friendly propulsion systems, including control equipment, and navigation technologies on the way to enabling autonomous navigation, improve safety, and increase efficiency.
- *Navigation and Positioning Technologies*: Leveraging advanced navigation and positioning technologies to enhance vessel navigation and ensure accurate and reliable positioning. This includes the utilization of Galileo satellite-based positioning systems and location-based services, to improve vessel navigation efficiency especially when improved accuracy is necessary, to support safe passing through locks and under bridges, and to enhance safety.
- *IoT and Connectivity Solutions*: Advanced connectivity solutions for vessels and barges in IWT. This involves the integration of sensors, data collection devices, and communication systems to enable real-time monitoring, tracking, and management of vessel operations. IoT solutions can provide valuable insights into vessel performance, cargo tracking, and operational efficiency, facilitating improved decision-making and resource optimization.

The results collected from the application scenarios form the foundation for driving capacity building initiatives and help shaping the IWT roadmaps and the pathways towards exploitation and commercialization of IW-NET solutions.

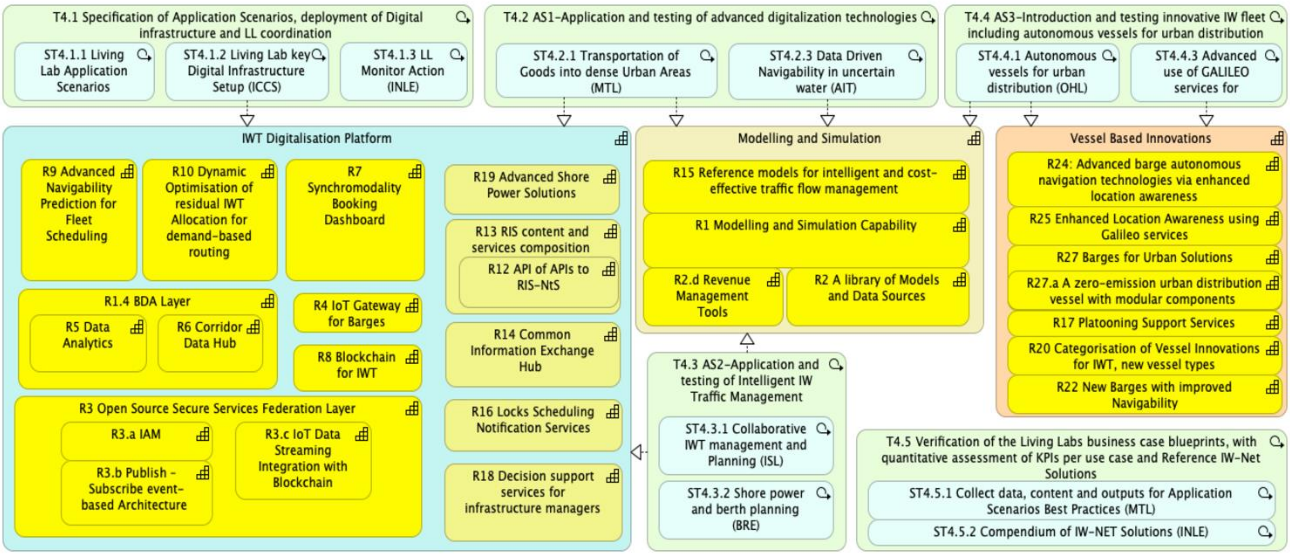

Figure 2: WP tasks and related project results.

The Application Scenarios AS1, AS2 and AS3 are mapped to tasks T4.2, T4.3 and T4.4 of IW-NET. Figure 2 shows how these tasks relate to the Outcomes (Results) of IW-NET which are produced in WP1, WP2 and WP3. The Digitalisation Architecture aggregates quite a few outcomes of WP1, and under T4.1 it is setup and deployed in the cloud to enable the connection and the exchange of information for the solutions deployed in the Application Scenarios.

1.2 Document Structure

The structure of this document is as follows:

- **Section 1** is the introduction, providing the context and the rational of this document.
- **Section 2** is describing the methodology aspects of the framework for the setup and monitoring of the Application Scenarios.
- **Section 3** presents Application Scenario AS1, providing an outlook of the two (sub) scenarios (AS1A, and AS1B), and a structured approach relating these to the Modal Shift Enablers, the Unique Value Points, KPIs and some initial high level user stories relating to it.
- **Section 4** presents Application Scenario AS2, providing an outlook of the two (sub) scenarios (AS2A, and AS2B), and a structured approach relating these to the Modal Shift Enablers, the Unique Value Points, KPIs and some initial high level user stories relating to it.
- **Section 5** presents Application Scenario AS3, providing an outlook of the two (sub) scenarios (AS3A, and AS3B), and a structured approach relating these to the Modal Shift Enablers, the Unique Value Points, KPIs and some initial high level user stories relating to it.
- **Section 6** is the conclusions section, with the most important conclusions.

1.3 Mapping of IW-NET Outputs

The purpose of this section is to map the commitments set out in the IW-NET Grant Agreement (GA), against the projects respective outputs that are presented in this deliverable. It also points out necessary changes to the scope of investigations.

Table 1: Adherence to IW-NET's GA Deliverables & Task Descriptions

DELIVERABLE	
D4.1: Specification of Application Scenarios, deployment of Digital infrastructure and LL coordination	**Living Lab application handbook which** describes the living lab infrastructure setup, living lab application scenarios, best practices, and proof of concepts.

TASKS	Respective Document Chapter(s)
T4.1 Specification of Application Scenarios, deployment of Digital infrastructure and LL coordination (m1-m34) The Application Scenarios of IW-NET will be investigating and testing: •Simulated models for Network capacity, reliability, and emissions. Strategic, Tactical and Operational optimisations analysis using the Revenue Management method. •Barges operations, including end-to-end visibility, using IoT for hierarchical tracking of logistics trade, with standards-based information exchanges, EPCIS-GS1, and transportation assets. •Synchro-modal collaboration, connecting seaports with containers, and use of River Transport for TEN-T corridor scenarios including city deliveries utilising predictive and prescriptive analytics and Collaborative multi criteria DSS tools. •Improved barge navigability using RIS infrastructure messages and notifications, and accurate location-based services with SBAS and EGNOS. •Autonomous Vessels distribution and new Vessels designs for environmentally friendly vessel types.	This document completely matches the description and outputs of T4.1 of IW-NET.

IW-NET GA Component Title	IW-NET GA Component Outline	Respective Document Chapter(s)
ST4.1.1 Living Lab Application Scenarios Handbook (INLE)	Produce the detailed plan of the Living Lab, including for each Application Scenario, the detailed specifications, the participant roles, governance, innovations focus, key use cases detailed descriptions and KPIs, and contextual knowledge to support investigation and testing of LL specific solutions. Further it sets the standards for the installation and technical validation of the IWT Digitalization Infrastructure and Services in the specific Application Scenarios.	Sections 2 is about the methodology, and Sections 3, 4 and 5 are about the Application Scenarios.
ST4.1.2 Living Lab key Digital Infrastructure Setup (ICCS)	Install configure and deploy IW-NET technology infrastructure components for each Application Scenario. Create all necessary cloud architecture components setup datastores, connectors, users, and roles. Perform initial testing.	Section 2.3 presents the digitalisation architecture setup.
ST4.1.3 Living Lab and monitor action (INLE)	Coordinate the running Application Scenarios, which will apply a similar agile implementation scheme of their subtasks, appropriately adapted for their needs and priorities.	The AS monitoring is reported with the Management Reports issued by IW-NET.

2 IW-NET Application Scenarios and Methodology

2.1 IW-NET Agile Methodology for the Application Scenarios

The IW-NET implementation plan aims to follow an agile approach, aligning the implementation activities with developments in WP1 to WP3 to integrate the digitalisation, IWT infrastructure related vessel automation and satellite accurate positioning enhancements provisions.

In the Living Lab, each Application Scenario applies the following pattern:

Scenario Analysis and Initial Setup M1-M6

Scenarios - Use Cases, Processes, Role descriptions, requirements for Collaboration. Key scenario description. Features identification, feasibility analysis and prioritization and identification of key quick-wins, creation of Backlog for feature development, testing and deployment, acceptance criteria setup. Proof of Concept for Application Scenario definition.

Feature Implementation M6-M30

Iterative agile process, where number of features, specific functionalities, specific small-scale experiments, and tests leading to the final Application Scenario demonstrator are coming to life, are deployed, and tested (e.g., navigation on static environment, then on small scale dynamic environment for automated barges, or incremental features and scenario simulations). For each Application Scenario, a full visibility for the (expected) final outcomes will be available by M18, with a Proof-of-Concept demonstrator.

Deployment, Testing and Assessment and Results collection and reporting M30-M36.

Feature collection periods will be set every six months, after the initial six-month setup period, where a full cycle of new features will be performed, all results will be collected to gradually build the Application Scenario storyline. There will be interaction with the roadmap activities of WP5.

2.1.1 Agile implementation via SCRUM and KANBAN

The Application Scenarios implementation plan involves applying the innovations developed in WP1, WP2, and WP3 to the IW-NET Application Scenarios AS1A, AS1B, AS2A, AS2B, AS3A, and AS3B.

The IW-NET agile implementation approach draws inspiration from a combination of **SCRUM** [1] and **KANBAN** [2] practices[1], hence, the Application Scenarios implementation should employ KANBAN for managing execution, solution implementation and deployment in an agile and iterative manner. In line with the KANBAN methodology, IW-NET applies an agile project management framework that emphasizes continuous delivery and improvement by limiting work in progress (WIP) and optimizing workflow efficiency. According to this approach and to meet the project reporting requirements, the project's agile lifecycle for all development tasks is being divided into two main reporting phases, aligning deliverables for availability at M18 and M36. Intermediate milestones link project activities and correspond to the project's Performance Measurement Indicators (PMIs) to guide progress towards implementation objectives. Key concepts from the Scrum methodology are adopted within IW-NET as follows:

- **User Stories**: Simple, high-level descriptions of features or requirements that capture user needs and serve as a basis for planning and implementation.
- **IW-NET Backlog:** A prioritized list of tasks expressed as user stories, based on Application Scenario requirements.
- **IW-NET Sprint:** A fixed period during which a specific set of tasks from the backlog is completed.
- **IW-NET Sprint Backlog**: A subset of the backlog for completion during a Sprint.

[1] https://www.scrum.org, https://kanbanguides.org

- **IW-NET Delivery Owner**: Responsible for defining and prioritizing the development backlog, ensuring the team stays on track and meets stakeholder needs. This role is assumed by the Task Leader of the corresponding Application Scenario.
- **IW-NET Sprint Master**: The facilitator leading the implementation team, removing obstacles and ensuring efficient and effective work. This role is also assumed by the Task Leader for the corresponding the Application Scenario.
- **IW-NET Sprint Review and Retrospective**: A meeting held at the end of each sprint to present completed work, gather feedback from stakeholders, and reflect on performance for improvement. This is normally performed each month, between the Task Leader and the Living Lab Work-Package Leader. Further, the 'retrospective' takes places with the end of each sprint in which the teams reflect on their performance and identify areas for improvement and is communicated at the Project Steering Team meeting.
- **Scrum Burn-Down Chart**: A management graph that indicates the of work remaining backlog, allowing the development teams to track progress.

According to the IW-NET agile approach for each application scenario, the implementation plan should be broken down into small steps based on user stories, which express user needs within an agile framework. User stories form the project's backlog, are prioritized, and added to the KANBAN monitoring process. To manage the evolution, implementation and delivery of the user stories, the methodology employs a KANBAN board, which serves as a visual representation of each Application Scenario of the implementation plan, with the following columns representing different stages of implementation:

- **Backlog**: Represents the pool of user stories under implementation.
- **To Do**: Contains tasks ready for implementation, typically representing tasks implemented through IW-NET Sprints.
- **In Progress**: Contains tasks currently being worked on, controlled to ensure a feasible set of activities within IW-NET Sprint execution.
- **Review**: Represents completed tasks for review, with the review process explained separately.
- **Done**: Contains tasks that have been completed and approved.

The *KANBAN board* is updated as tasks progress through the different stages of implementation, reflecting their status. Scrum meetings are held by the IW-NET teams to review progress, address obstacles, and plan the next steps, ensuring the Application Scenario implementation stays on track and focused.

2.1.2 Agile implementation lifecycles for the Application Scenarios

For Every application scenario, which involves a number of use cases, IW-NET defines a development lifecycle to be run throughout the project lifetime. In the following best Project Management Practice set of tasks are advised to be performed for every application scenario[2].

Scenario Analysis and Initial Setup (M1-M6)
• Conduct a detailed analysis of scenarios, use cases, processes, and role descriptions. • Define requirements for collaboration and identify key features. • Perform feasibility analysis, prioritize features, and identify key quick wins. • Create a backlog for feature development, testing, and deployment. • Set up acceptance criteria for each feature. • Develop a proof of concept for the Application Scenario definition.
Feature Implementation Iteration A (M6-M18)
• Adopt an iterative agile process with timeboxed Sprints (e.g., 4 weeks) for implementing features. • Develop the plan of the first implementation cycle, create a backlog of tasks for each. • Prioritize features from the backlog for each Sprint based on their importance and dependencies. Present the plan to the executive board and stakeholders, collect feedback, and make necessary changes. • Implement and test specific functionalities within each Sprint. • Utilize the Kanban to monitor the progress and the Kanban board as a visual representation of the overall implementation plan, with columns representing different stages (e.g., Backlog, To-Do, In Progress, Review, Done). • Use Kanban to prioritise tasks as necessary and perform adjustments. Regularly update the Kanban board to reflect the status of tasks as they move through the stages. • Perform monitoring, risk management, and mitigation, collect data for KPIs and reporting. • Conduct Sprint Review and Retrospective meetings at the end of each Sprint to present completed work, gather feedback, and identify areas for improvement.
Feature Implementation Iteration B (M18-M30)
• Continue the iterative agile process with timeboxed Sprints for implementing the remaining features. • Develop the plan of the second implementation cycle, create a backlog of tasks for each Prioritize features based on their importance and dependencies, considering the progress made in Iteration A. Present the plan to the executive board and stakeholders, collect feedback, and make necessary changes. • Implement and test specific functionalities within each Sprint. • Update the Kanban board to reflect the status of tasks and track progress. • Conduct Sprint Review and Retrospective meetings at the end of each Sprint to gather feedback and identify areas for improvement.
Deployment, Testing, Assessment, Results Collection, and Reporting (M30-M36)
• Complete the implementation of all features. • Conduct thorough testing and assessment to ensure the functionality, reliability, and performance of the implemented features. • Collect all results and analyze them to evaluate the effectiveness and impact of the implemented features. • Collaborate with roadmap activities in WP5 to align with project objectives and timelines. • Regularly review and update the Kanban board to track progress and ensure that work remains focused and on track.

[2] Depending on the nature of the implementation i.e., whether it is about application development, integration of systems, construction of a barge and installation of equipment, Application Scenarios have the flexibility to adapt their agile approach lifecycle.

2.1.3 Design Thinking Methodology for AS2

For AS2 the *Design Thinking* approach (Figure 3) was adopted, a commonly used methodology in software development projects. Design Thinking is a systematic, human-centered approach for solving complex problems within all aspects of life, which means that user needs and requirements as well as user-oriented invention are central to the process.

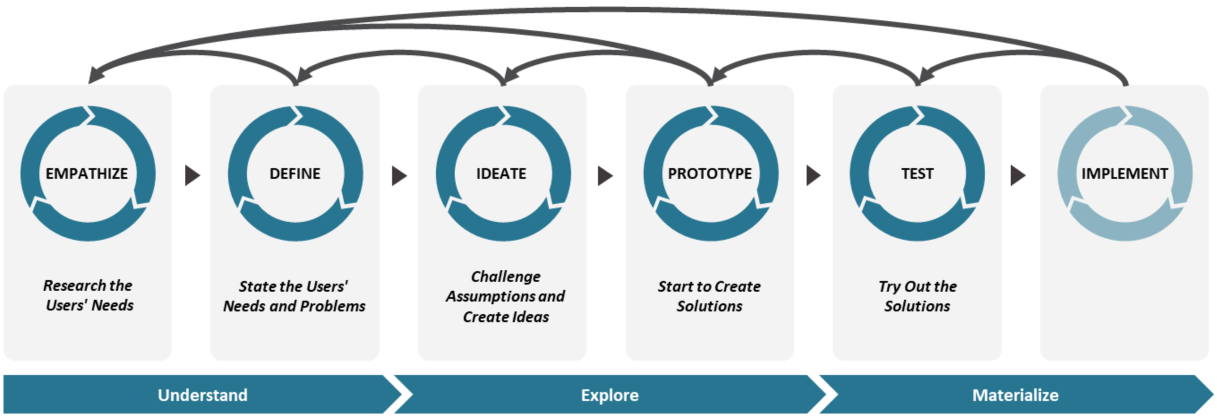

Figure 3: Design Thinking Approach

Design Thinking includes several steps which are divided into three main phases: (a) the *Understand* phase, which includes *Empathize* and *Define* steps, (b) the *Explore* phase which includes the *Ideate*, and *Prototype* steps, and the (c) *Materialize* phase which includes the *Test* and *Implement* steps.

2.2 Establishing an analysis framework for the Living Lab

2.2.1 IW-NET Modal Shift Enablers and Application Scenarios

The Application Scenarios implementation plan involves applying the innovations developed in WP1,

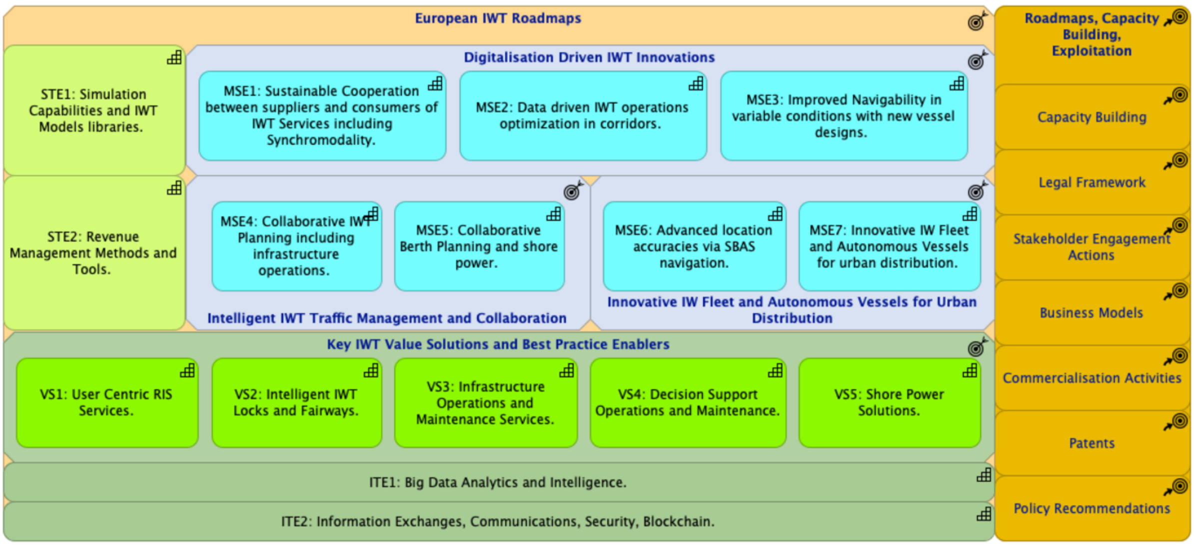

Figure 4: IW-NET Enablers Framework

All project components have been captured and are analysed using the Archimate 3.2 framework [3][3].

As a result, an evolving and fully interconnected model has been created, where project aspects have been captured and mapped using the various modelling levels of Archimate, more specifically the (a) Motivation Layer has been used to capture Stakeholders, Drivers, Goals, Outcomes, Assessments and

[3] https://pubs.opengroup.org/architecture/archimate32-doc/index.html , Also see in Annex the Archimate Methodology Elements.

Impacts, the (b) Strategy Layer to capture Resources and Capabilities, also Courses of Action and Value Streams, the (c) Business Layer to define and link Business Services, Actors, Roles while defining the Digitalisation Architecture, also the (d) Application and Technology Layers were introduced to capture the Architecture components and to link it to the project structure using the Implementation and Migration Layer.

The Modal Shift Enablers (see Figure 4) provide valuable context to the Application Scenarios definition, so they are quite important contributing to the Application Scenarios analysis letting create a taxonomy of solutions. The mapping between the Application Scenarios and the Modal Shift Enablers is detailed in the Sections; Section 3, Section 4 and Section 5 of this document.

2.2.2 IW-NET Unique Value Propositions and application scenarios

Figure 5: Unique Value Points of IW-NET. (UPV1 – UPV5)

The Unique Value Points of IW-NET (see Figure 5 and Figure 6) provide a deeper analysis on the expectations for the project's value driven outcomes, thereby setting the context to the Application Scenarios, as regards their contribution towards these outcomes. The mapping between the Application Scenarios and the Unique Value Points is detailed in the Sections; Section 3, Section 4 and Section 5 of this document.

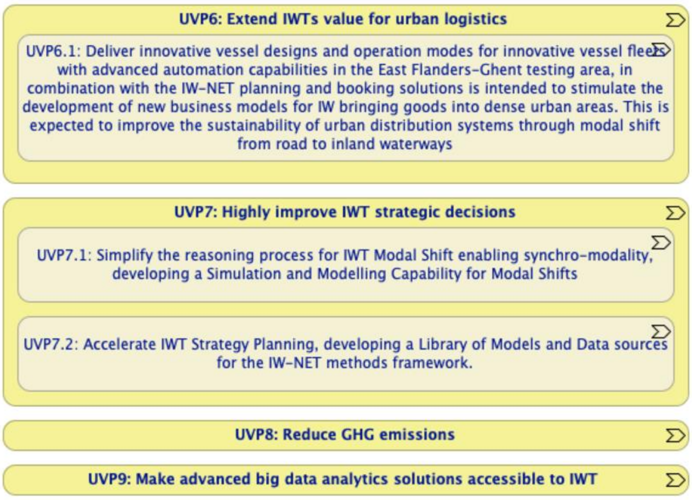

Figure 6: Unique Value Points of IW-NET. (UPV6 – UPV9)

2.3 The IW-NET Digital Infrastructure

2.3.1 Overview

The advanced Information and Communications technologies, integrated and further developed in IW-NET provide a foundation for the digital transformation of IWT, enabling the seamless information sharing, data analytics, and secure transactions. They aim to empower stakeholders with data-driven decision-making capabilities and to support the optimization of resources and the modal shift to IWT.

The digitalisation technologies developed within IW-NET have been selected as being instrumental in driving the digital transformation of IWT services. They provide the foundation for data-driven decision-making, resource optimization, and seamless integration of multimodal routes. The data and analytics architecture, along with IoT sensors, enable real-time data availability, facilitating revenue management optimization and end-to-end tracking of goods. The insights generated through analytics and forecasting tools empower stakeholders to make informed decisions at tactical, operational, and execution levels.

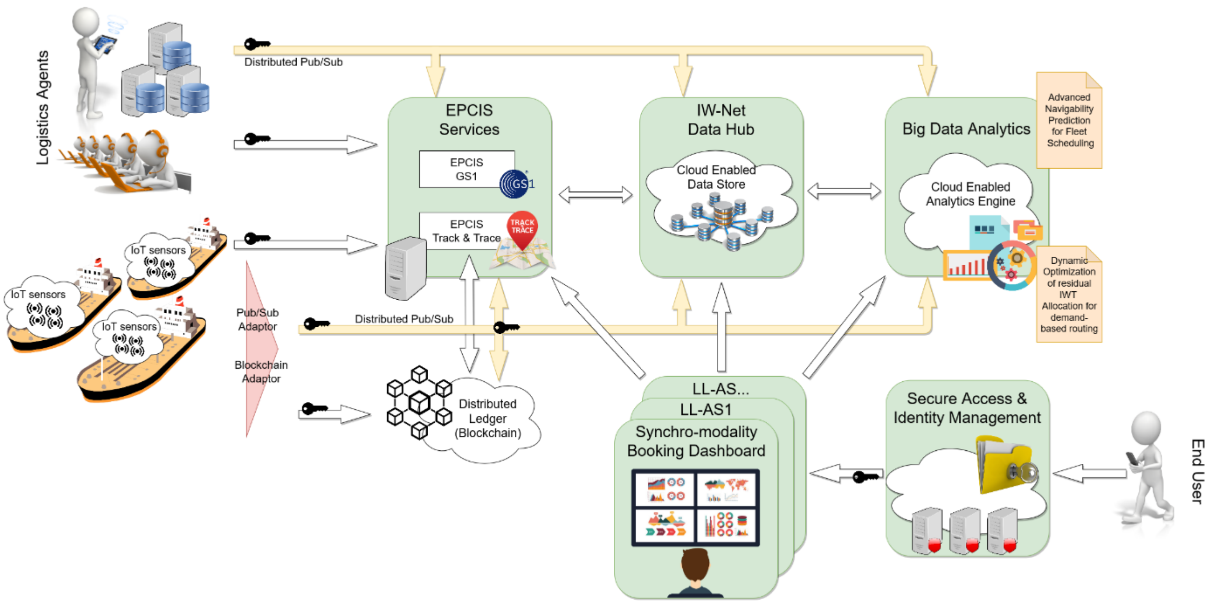

Figure 7: A high-level overview of the architectural components.

A high-level overview of the architecture of digitization technologies developed and deployed in the context of IW-NET is depicted in Figure 7. This set of services provides a highly integrated toolkit implementing state-of-the-art levels of security, better visibility of operations, sustainable and large-scale operational data collection, real-time monitoring and automation of decision making-processes.

More specifically, they include the development of a data and analytics architecture, IoT sensors, synchro-modal booking, and resource optimization systems, blockchain-based smart contracts, and analytics and forecasting tools. The integration of these technologies enables the seamless sharing of information, efficient planning and allocation of resources, and the implementation of secure and transparent transactions within the IWT ecosystem.

The communication between various services and applications that comprise the technological stack of IW-NET takes place through a distributed, secure, and scalable message exchange system that follows the Publish-Subscribe paradigm. The deployment of a dedicated Secure Access and Identity Management Service ensures that data access is regulated and follows specific rules. At the same time, edge devices such as IoT sensors, developed within the context of IW-NET, and existing data sources originating from the operational level of the industry provide a rich data flow that utilizes the aforementioned technologies to reach the processing centres where insightful data processing tasks take place.

The integration of GS1-compliant track and trace systems, enables hierarchical cargo tracking and synchro-modal operations in dense urban areas. This integration optimizes the utilization of transportation networks, improves efficiency, and supports modal shift from road to waterways, resulting in reduced congestion, carbon emissions, and environmental impact. The influx of real-time data into the system is steered into the stream analytics processing engines, which can be programmed to offer live insights into the operational process, detect anomalies and produce warnings whenever necessary.

Furthermore, the use of blockchain technology in IW-NET enhances the security and transparency of transactions within the IWT ecosystem. By leveraging blockchain-enabled smart contracts, stakeholders can establish trusted relationships, automate service booking and planning, and optimize revenue management. The immutable record of transactions provided by blockchain ensures the authenticity of data, enables secure traceability, and fosters collaboration among small and medium-sized enterprises (SMEs) by streamlining service synchronization and goods grouping.

2.3.2 Infrastructure properties and application deployment

The technologies and services presented in Figure 7, have been presented and documented in the deliverables of WP1, and more specifically in the deliverables D1.5, D1.6[4] and D1.7[5]. Prototypes of the technical solutions are currently in various stages of development and testing lifecycle. Most of the components have been deployed locally in private infrastructure hosted at the premises of the partners responsible for their development. Technological advances in the fields of networks and cloud computing allow us to deploy these prototypes in a distributed design and interconnect their services over lightning-fast networks.

The two main components that guarantee the security and reliability of message exchanges and inter-component interactions are accessible and utilized by all other technical solutions that implement the distinct components:

[4] D1.5 and D1.6: “Big Data analytics linked with IWT corridor data hub”, Versions 1 and 2
[5] D1.7 : “Synchro-modality booking and execution management dashboard and architecture extensions, dynamic optimisation”, Version 1.

- The component that implements Identity and Access Management (IAM), has been configured to allow access to appropriate shared resources for the various components, based on agreed-upon rules.
- The distributed Publish-Subscribe mechanism acts as the central communication hub in the proposed architecture and has been integrated with a large number of the prototypes of components described in the respective deliverables of WP1, allowing them to exchange information and interact with each other, in a secure and reliable way.

These two components work in tandem, ensuring that the distributed nature of the IW-NET designed system can work as a unit, maintaining its ubiquitous design principles which have intentionally been as generic as possible.

The IW-NET design choices give us the flexibility to utilize the same infrastructural solutions in the context of numerous scenarios and use-cases instead of the costly option of producing a specialized solution to address each one specifically. In the IW-NET approach, the infrastructural architecture remains immutable, and the applications designed to tackle specific problems in the IWT domain are developed and deployed on top of it, therefore presenting a viable and maintainable suggestion where the business logic is implemented at the top of the technological stack.

The digitalisation architecture first became available in M12, following the training of the technical users of how to use the various services and facilities provided. The Blockchain extensions were installed by M18, and since then it receives regular updates and upgrades, using open-source software options which has been uploaded in Github[6].

2.4 IW-NET Assets

The IW-NET implementation plan in the solutions-oriented work-packages (WP1, WP2 and WP3), develops, configures and integrates the components shown in Figure 8.

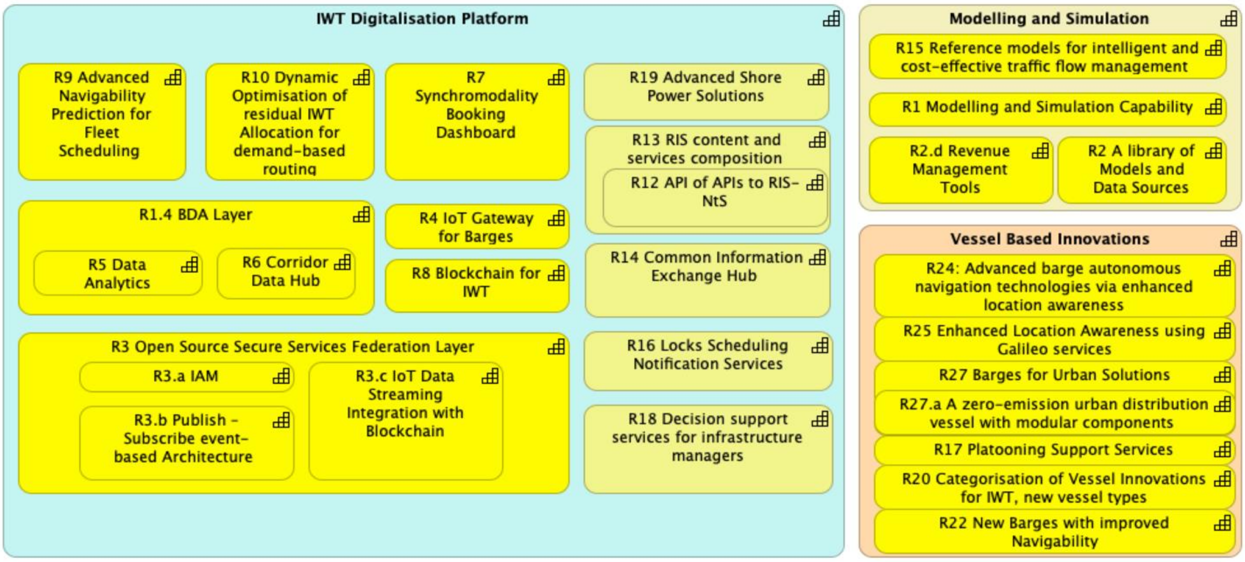

Figure 8: IW-NET developed and integrated Assets.

[6] https://github.com/iwnet/digitalization-infrastructure

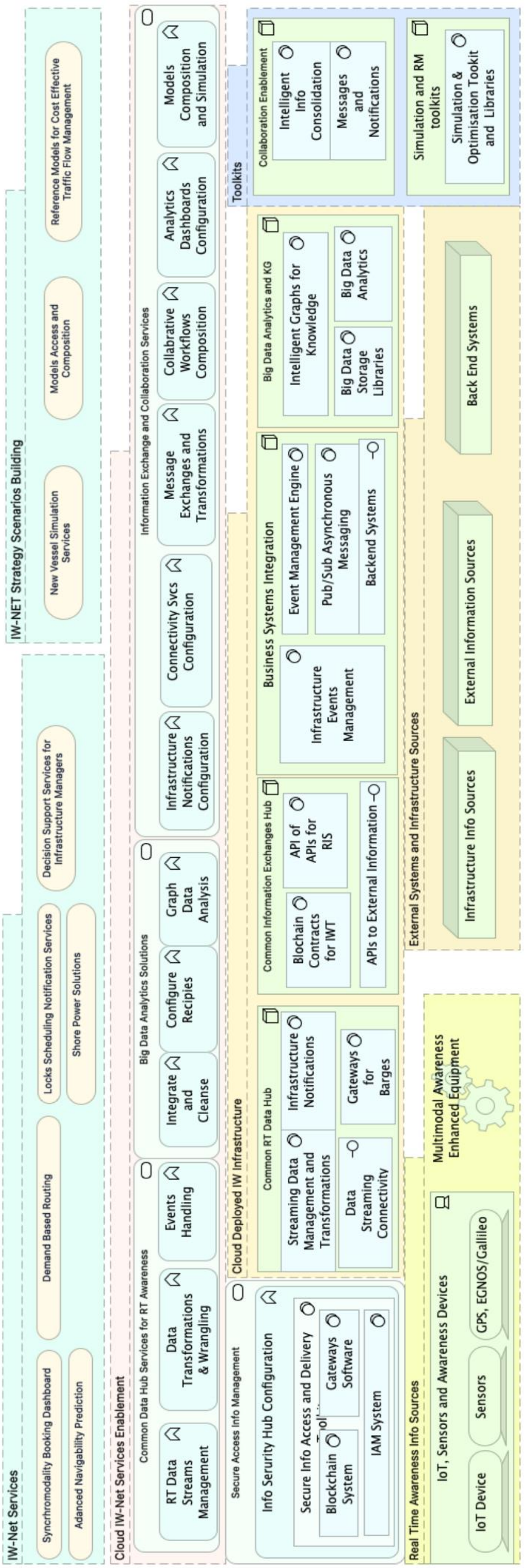

Figure 9: IW-NET Functional Architecture

The functional components of the architecture supporting the implementation of the above assets are shown in Figure 9. For every application scenario and for every work-package analysis there exists a mapping between the that scenario and the related IW-NET assets, and their corresponding implementation architecture components.

2.5 IW-NET Stakeholders

The IW-NET application scenarios involve several stakeholders:

IWT Service Providers: Offering inland waterway transport services, they are responsible for operating vessels and transporting goods via waterways.

Supply Chain Stakeholders: Including shippers, freight forwarders, and logistics companies. They collaborate with inland waterway transport service providers to ensure efficient and reliable transportation of goods.

Barge Operators: These are companies or individuals who operate barges for inland waterway transport.

Waterway Authorities: Responsible for managing and regulating the waterways and the navigation and safety of IWT, ensuring compliance with regulations and guidelines.

IWT Management Authorities: Responsible for managing and planning IWT operations.

Port Authorities: Manage and operate ports along inland waterways.

Vessel Manufacturers: Companies involved in designing and manufacturing IWT vessels, interested in designing, developing, and testing innovative vessel designs and technologies.

Urban Logistics Stakeholders: Including retailers, e-commerce companies, and logistics providers operating in urban areas. Interested on innovative solutions such as autonomous vessels for last-mile delivery and urban distribution.

Vessel Operators and Navigators: Responsible for operating and navigating inland vessels. They adopt and utilize advanced navigation technologies, including GALILEO services, to improve navigation accuracy and safety.

3 AS1 - Digitalisation technologies

3.1 Application Scenario 1A (AS1A), Application and testing of advanced digitalization technologies

Application Scenario 1A (AS1A, see summary card Figure 10) aims to apply and test advanced digitalization technologies that enhance the competitiveness and efficiency and sustainability of inland waterway transportation (IWT) services in urban areas. The primary objective of AS1A is to address various challenges faced by IWT, including improving network efficiency, real-time tracking and monitoring of freight flows, optimizing resource allocation, and enhancing collaboration among stakeholders.

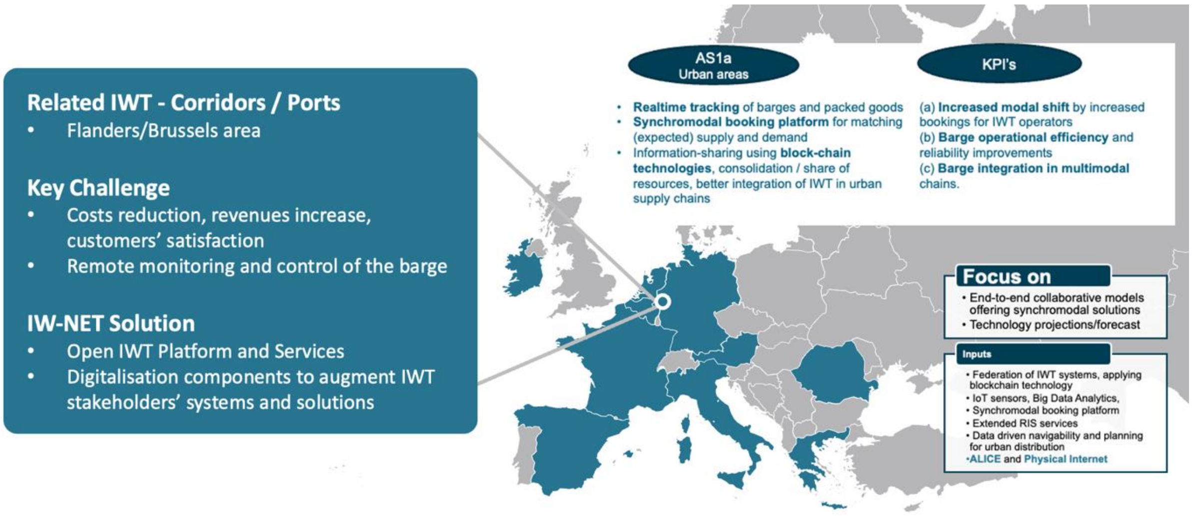

Figure 10: AS1A Summary Card

AS1A focuses on enhancing flexibility, speed, and availability of IWT services through real-time tracking, synchro-modal operations, and blockchain-enabled collaboration, and on applying and testing advanced digitalization technologies to address challenges in IWT services within urban areas. The technologies developed within IW-NET WP1 provide the foundation for the digital transformation, enabling seamless information sharing, data analytics, and secure transactions; they empower stakeholders with data-driven decision-making capabilities and support the optimization of resources and multimodal route selection. To this end, the AS1A related technologies include the development of a data and analytics architecture, selection configuration, integration, and deployment of IoT sensors connected via specifically developed gateways to the IW-NET digital architecture, synchro-modal booking, and resource optimization systems, blockchain-based smart contracts, and analytics and forecasting tools. The integration of these technologies enables the seamless sharing of information, efficient planning and allocation of resources, and the implementation of secure and transparent transactions within the IWT ecosystem.

In AS1A the above enhancements of transportation services are expected to be achieved through accurate real-time tracking of freight flows, which provides end-to-end seamless visibility, monitoring, and forecasting of incoming and outgoing transportation flows. Advanced location services are leveraged to optimize service planning and operations, enable predictive demand routing, and integrate different customer categories and market segments to improve profitability.

Further, with the integration of GS1-compliant track and trace solutions, AS1A tests hierarchical cargo tracking and synchro-modal operations in dense urban areas. This integration optimizes the utilization of transportation networks, improves efficiency, and supports modal shift from road to waterways, resulting in reduced congestion, carbon emissions, and environmental impact.

The use of blockchain technology enables AS1A scenarios to achieve the enhanced security and transparency of the transactions taking place within the IWT ecosystem. By leveraging blockchain-enabled smart contracts, stakeholders can establish trusted relationships, automate service booking and planning, and optimize revenue management. The immutable record of transactions provided by blockchain ensures the authenticity of data, enables secure traceability, and fosters collaboration among small and medium-sized enterprises (SMEs) by streamlining service synchronization and goods grouping.

When upscaled, the technologies developed within IW-NET WP1 can be considered instrumental in driving the digital transformation of IWT services, setting the foundations for data-driven decision-making, resource optimization, and seamless integration of multimodal routes. The data and analytics architecture, along with IoT sensors, enable real-time data availability, also facilitating revenue management optimization and end-to-end tracking of goods. While the insights generated through analytics and forecasting tools empower stakeholders to make informed decisions at tactical, operational, and execution levels.

AS1A's success will be measured through key performance indicators (KPIs) such as increased modal shift, improved barge operational efficiency, and seamless integration within multimodal chains. These KPIs reflect AS1A's objectives of enhancing the competitiveness, efficiency, and sustainability of IWT services in urban areas.

3.2 Application Scenario 1B (AS1B), Data Driven navigability in uncertain water

The AS1B application scenario (see summary card in Figure 11Figure 10) focuses on leveraging data-driven optimization to address the challenges of variable navigability in uncertain water conditions. The specific focus is placed in Danube, with the aim of optimizing barge operations via the exploitation of valuable data about the river water level conditions also to the design of new types of barges that are optimized efficient and effective for Danube navigability.

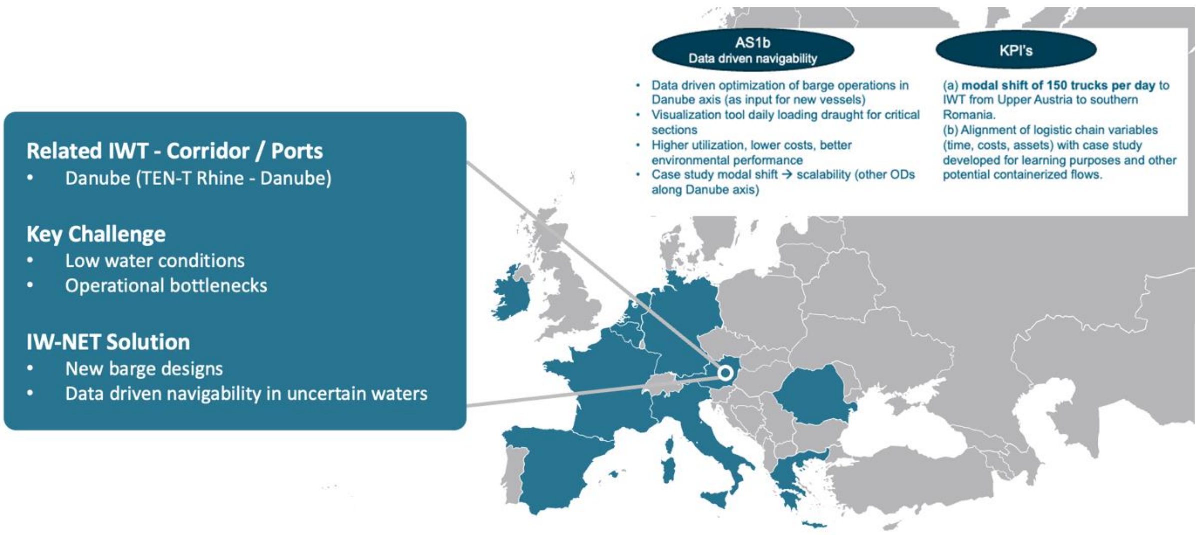

Figure 11: AS1B Summary Card

The corridor from the Port of Enns (Austria) to Giurgiu (Romania) serves as the testing ground for the business case. The key scenario for AS1B revolves around the modal shift case, where the goal is to shift 150 trucks per day from Upper Austria to southern Romania using the waterway.

The success of this shift depends on several factors, including the infrastructure and water levels along the Danube. Considerations such as cost calculations, logistical planning, and the overall feasibility of the modal shift are integrated in this scenario.

Hence, the setup and concept proofing of AS1B involves two key use cases, which involve new barge design analysis and the Danube Living Lab analysis to provide a solid foundation for the scenario, supporting the goals of enhancing efficiency, competitiveness, and sustainability in inland waterway transport along the Danube.

3.2.1 Use Case UC-1: New Barge Design Analysis

The focus is on examining and evaluating different designs of barges to determine which type is best suited for specific purposes. Different versions of barges are analysed, considering factors such as stability, building costs (including analysis of steel prices), and alternative material options. The assessment includes considerations of strength, lightship weight, nautical consequences, and investment costs for different material choices. This analysis forms the foundation for developing optimized barge designs that can effectively navigate the Danube under uncertain water conditions.

3.2.2 Use Case UC-2: Danube Water levels monitor

The Danube Living Lab is dedicated to analysing the Danube Ports, water levels, and relevant statistics. This analysis is essential for a specific modal shift case, where goods from Nothegger Transport Logistik GmbH need to be transported from Austria to Romania via the waterway. To support this use case, a visualization tool is being developed to depict the loading draught for critical stretches along the Danube, from upstream to downstream. This tool enables the assessment of water levels and aids in decision-making related to optimal loading capacities and navigation planning.

3.3 AS1 relevance with the MSEs of IW-NET

AS1 contributes to the objectives of enhancing the competitiveness, efficiency, and sustainability of IWT services. The application and testing of advanced digitalization technologies and data-driven optimization techniques are instrumental in achieving these objectives (seeTable 2).

- In AS1A, the impact and outputs of the MSEs can be demonstrated through the implementation of synchro-modal operations, improved operational efficiency, reduced logistics costs, and increased collaboration among stakeholders. Key performance indicators (KPIs) such as modal shift, cost savings, and the number of participants engaged in cooperative activities can be used to measure the success of AS1A.
- In AS1B, the impact and outputs of the MSEs can be demonstrated through optimized barge designs, improved navigability in uncertain water conditions, and increased reliability of waterway transport along the Danube. KPIs such as barge operational efficiency, reduction in delays due to water level variations, and cost savings from optimized designs can be used to measure the success of AS1B.

Table 2: MSEs for AS1

AS1A - Application and Testing of Advanced Digitalization Technologies	
MSE1: *Sustainable cooperation between suppliers and consumers of IW transportation services, including synchro-modality.*	Demonstrates sustainable cooperation by enabling synchro-modal operations and collaboration between suppliers and consumers of IWT services. The impact can be measured by assessing the increase in synchro-modal operations, the number of participants engaged in cooperative activities, and the reduction in logistics costs due to improved coordination.
MSE2: *Data-driven IWT operations optimization in corridors.*	Utilizes data-driven optimization techniques to optimize IWT operations in urban areas. The impact can be measured by evaluating the improvement in operational efficiency, resource utilization, and on-time deliveries through data-driven decision-making.

MSE4: *Collaborative IWT planning, including infrastructure operations.*	Facilitates collaborative planning among stakeholders, including infrastructure operators, to optimize IWT services in urban areas. The impact can be measured by assessing the effectiveness of collaborative planning in reducing bottlenecks, improving resource allocation, and enhancing overall operational efficiency.
AS1B - Data-driven Navigability in Uncertain Water	
MSE2: *Data-driven IWT operations optimization in corridors.*	Leverages data-driven optimization to address the challenges of variable navigability in uncertain water conditions along the Danube. The impact can be measured by evaluating the improvement in barge operational efficiency, reduction in delays due to water level variations, and increased reliability of waterway transport.
MSE3: *Improved navigability in variable conditions with new vessel designs.*	Focuses on analysing and evaluating different barge designs to optimize their performance in variable water conditions. The impact can be measured by assessing the effectiveness of new barge designs in navigating uncertain water levels, improving stability, and reducing operational costs.

3.4 AS1 value contribution on the Unique Value Points (UVPs) of IW-NET

Application Scenario 1A (AS1A) focuses on applying and testing advanced digitalization technologies to improve the competitiveness and efficiency of inland waterway transportation (IWT) services in urban areas. AS1A aims to enhance flexibility, speed, and availability of IWT services through real-time hierarchical tracking, which is standards based on GS1, synchro-modal operations, and blockchain-enabled collaboration. The integration of technologies such as data analytics, IoT sensors, synchro-modal booking systems, and blockchain-based smart contracts enables seamless information sharing, resource optimization, and secure transactions within the IWT ecosystem. AS1A's success is measured as increased modal shift, improved barge operational efficiency, and seamless integration within multimodal chains. AS1A contributes to various UPVs by evaluating and assessing the implementation of advanced digitalization technologies and innovative solutions in IWT, leading to improvements in efficiency, sustainability, collaboration, decision-making, and environmental impact.

Application Scenario 1B (AS1B) focuses on data-driven optimization to improve navigability in uncertain water conditions. AS1B optimizes barge operations by leveraging valuable data on river water level conditions and designing new types of barges optimized for Danube navigability. The success of AS1B is measured through barge operational efficiency, reduction in delays caused by water level variations, and cost savings from optimized designs. AS1B contributes to various UPVs by evaluating and assessing the implementation of data-driven decision-making for operational efficiency, and service performance in IWT.

AS1 contributes to the formation and value creation of the UVPs of IW-NET as follows (see Table 3):

Table 3: AS1 Unique Value Points (UPVs)

Unique Value Points	AS1A	AS1B
UVP1: Support modal shift to Inland Waterways Transport (IWT) by optimizing services and operations, improving real-time visibility, and enabling efficient tracking.	AS1A supports UVP1 by evaluating the implementation of synchro-modal options and advanced decision support tools, optimizing IWT services and operations, and assessing the improvements in efficiency, reliability, and sustainability achieved through synchro-modal operations. GS1 EPCIS with hierarchical	

	tracking and full delivery visibility is implemented.	
UVP2: Enhance collaboration in IWT services by facilitating secure and seamless information exchange, improving the management of residual IWT capacity, and providing real-time barge transportation options.	AS1A supports UVP2 by evaluating the implementation of open-source secure services and information sharing, assessing the effectiveness of these solutions in improving collaboration and information exchange in IWT. Revenue Management methodology and simulations are used. Information exchanges are based on GS1 standard. RIS information is based on EURIS.	
UVP3: Streamline and optimize IWT planning processes with the help of advanced algorithms and big data analytics. This also includes enabling real-time traffic information and using IoT for automation.	AS1A supports UVP3 by evaluating the algorithms, models, and data sources used for accurate estimations and predictions in IWT planning, optimizing planning processes, and assessing the impact of improved planning on the accuracy, reliability, and efficiency of IWT operations. AS1A supports UVP3 by providing real-time information, booking, and monitoring services to IWT SMEs, enabling their access to advanced technology options and data-driven strategies, and evaluating the feasibility and benefits of utilizing big data analytics for optimizing operations	
UVP4: Advance vessel technology by promoting innovative vessel types, introducing blockchain solutions for cargo shipping, and establishing Galileo as the benchmark solution for high precision positioning in IWT.		AS1B assesses the effectiveness in enhancing vessel navigability and reliability. It evaluates the capabilities and potential benefits as cost reduction, CO2 reduction, and improvement loading and unloading performance.
UVP6: Extend IWT's value for urban logistics by applying innovative vessel designs and operation modes to improve the sustainability of urban distribution systems.	AS1A supports UVP6 by evaluating innovative solutions for Urban Logistics using IWT and environmentally friendly last mile deliveries based on cargo bikes, assessing their impact on promoting modal shift and reducing the environmental impact of transportation in urban areas, and providing insights into the potential of innovative vessel fleets to drive sustainable and efficient transportation.	
UVP7: Improve strategic decisions in IWT by simplifying the modal shift reasoning process, accelerating strategy planning, and creating a best practices portfolio. This includes the development of EU IWT roadmaps and roadmaps for policy impact.	AS1A supports UVP7 by developing simulation and modelling capabilities for modal shift and synchro-modality, assessing their impact on strategic planning, network resilience, and efficient resource allocation in synchro-modal operations, and simplifying the reasoning process for modal shift in IWT.	AS1B supports the validation of scenarios to shift transport to IWT and defines requirements for modal shift roadmaps and policy impact.
UVP8: Reduce GHG emissions by ensuring IWT operations follow the	AS1A supports UVP8 by evaluating the environmental benefits and feasibility of implementing synchro-modal options, such as	AS1B supports UVP8 by testing sustainable vessel designs for Danube navigation

latest standards in the Global Logistics Emissions Council, the GLEC framework, and the forthcoming ISO process.	modal shift from road to inland waterways, assessing the impact of these measures on reducing GHG emissions in IWT operations, and ensuring compliance with emissions accounting and reporting standards.	requirements, and operation modes, evaluating their effectiveness in reducing GHG emissions in IWT operations, and developing designs to better plan containers and loading unloading configurations.
UVP9: Make advanced big data analytics accessible to IWT SMEs by providing an open-source big data analytics environment and a library of recipes.	AS1A supports UVP9 by delivering an open-source big data analytics environment and a library of recipes designed for IWT SMEs, assessing the accessibility and effectiveness of advanced technology options, and enabling SMEs to leverage data-driven strategies for optimizing their services and operations in IWT	

3.5 AS1 User Stories

Using the Agile approach based on User Stories, which are implemented via the AS activities, there follows a set of initial and high-level user stories is provided for the Application Scenario AS1A.

	AS1A User Stories
Who: *What:* *Why:*	As a logistics manager, I want to have real-time visibility of inland waterway transport (IWT) services, to optimize the use of resources and improve operational efficiency.
Who: *What:* *Why:*	As a transportation provider, I want to access user-oriented dashboards that provide synchro-modal information, allowing me to plan and optimize IWT services.
Who: *What:* *Why:*	As a logistics planner, I want to consolidate and distribute relevant information, including RIS-related data and notification services messages, to improve synchro-modal collaborations and operations.
Who: *What:* *Why:*	As a cargo owner, I want to track and monitor my shipments in real-time across different modes of transport, including cross-border deliveries, using IoT solutions and secure IoT gateways, I want to track and monitor my shipments.
Who: *What:* *Why:*	As a logistics coordinator, I want hierarchical tracking to link transport means (bikes, vehicles, and vessels) and cargo, providing end-to-end visibility on operations.
Who: *What:* *Why:*	As a customer, I want to receive real-time updates on the estimated time of arrival (ETA) of each logistics unit, automated updates on unit status, and electronic proof of delivery at each step, to improve my operations.
Who: *What:* *Why:*	As an IWT SME operator, I want access to real-time information on barge transportation options, costs, and availability of inland terminals, to participate fully in the IWT market networks.
Who: *What:* *Why:*	As a logistics manager, I want to optimize the use of IWT resources in synchro-modal collaboration scenarios, to ensure efficient tracking and seamless information exchange between infrastructures and stakeholders.

In the following a set of high-level user stories is provided for the Application Scenario AS1B.

	AS1B User Stories
Who: *What:* *Why:*	As a barge operator, I want access to real-time data on water level conditions, to optimize navigation planning and ensure safe and efficient operations.
Who:	As a logistics planner,

What: *Why:*	I want to analyse different barge designs and evaluate their suitability for navigating uncertain water conditions on the Danube river.
Who: *What:* *Why:*	As a transportation manager, I want to shift a specific number of trucks per day from Upper Austria to southern Romania using the waterway, reducing road congestion and environmental impact.
Who: *What:* *Why:*	As a barge operator, I want to reduce delays caused by water level variations by using advanced navigational tools and real-time water level data, to reduce delays.
Who: *What:* *Why:*	As a logistics coordinator, I want to optimize loading capacities based on Danube water levels t to maximize efficiency and avoid disruptions.
Who: *What:* *Why:*	As a sustainability manager, I want to quantify the cost savings and environmental benefits achieved through optimized barge designs and improved navigation in uncertain water conditions, to plan my operations.
Who: *What:* *Why:*	As a cargo owner, I want to track and trace my shipments, with real-time visibility on the impact of water level variations on delivery times and logistics operations, to plan my operations
Who: *What:* *Why:*	As a barge captain, I want to receive accurate and timely information on water level changes and their potential impact on navigation safety, to allow me to make informed decisions.
Who: *What:* *Why:*	As a port authority, I want to collaborate with barge operators and logistics stakeholders to improve navigability, to ensure smooth operations.

3.6 AS1 KPIs

In the following a set of high level KPIs related to the Application scenarios AS1A and AS1B is listed in table (Table 4). The table brings some indicative KPIs while the actual KPIs for the Application Scenarios A1 will be defined in deliverable D4.2.

Table 4: KPIs AS1

AS1A - Application and Testing of Advanced Digitalization Technologies indicative KPIs	
Percentage increase in modal shift from road transport to inland waterway transport (IWT).	Measures the shift in cargo transportation from roads to inland waterways, indicating the adoption and effectiveness of IWT services.
Reduction in barge operational costs achieved through the optimization of services and operations.	Measures the cost savings achieved by optimizing barge operations and services, reflecting increased efficiency and reduced expenses using Revenue Management.
Increase in real-time visibility of cargo and transport resources in synchro-modal operations.	Measures the improvement in real-time visibility of cargo and transport resources, enabling better coordination and synchronization of operations.
Number of advanced GS1 messages and notifications provided to improve service resilience and reliability	Measures the quantity of notifications and alerts provided as GS1 message implementations to support decision-making, enhancing service resilience and reliability.
Reduction in greenhouse gas emissions through the adoption of advanced digitalization technologies.	Measures the decrease in greenhouse gas emissions resulting from the adoption of advanced digitalization technologies, indicating environmental benefits.

AS1B - Data-driven Navigability in Uncertain Water indicative KPIs

Reduction in delays caused by water level variations through data-driven optimization.	Measures the decrease in delays caused by water level variations, reflecting the effectiveness of data-driven optimization in mitigating navigational challenges
Increase in barge operational efficiency achieved by leveraging data on river water level conditions.	Measures the improvement in barge operational efficiency resulting from the utilization of data on river water level conditions, indicating better navigational planning.
Cost savings from optimized barge designs that are tailored to navigate uncertain water conditions.	Measures the monetary savings achieved through optimized barge designs that can efficiently navigate uncertain water conditions.
Improvement in navigability and traffic flow on the Danube River.	Measures the enhancement in reliability to navigability and traffic flow on the Danube River, reflecting improved waterway predictions for conditions and reduced risks.
Reduction in environmental impact through optimized designs and efficient barge operations.	Measures the decrease in environmental impact resulting from optimized designs and efficient barge operations, indicating improved sustainability.

4 AS2 - Intelligent IW Traffic Management

AS2 aims to enhance the efficiency, reliability, and sustainability of inland waterway transport in this corridor by leveraging advanced digitalization technologies. The geographical context of AS2 is Northern Germany, specifically addressing the hinterland connections of Bremerhaven via the River Weser and the Mittelland Canal. This region experiences strong competition between inland navigation and other transportation modes due to its accessible road and rail networks and short transport distances to important inland hubs.

AS2 has its primary focus is on developing and implementing intelligent traffic management solutions for inland waterways and it is closely aligned with the work carried out in IW-NET WP2 (IWT Infrastructure improvements and TEN-T, Sea, and Inland Ports Integration), while it benefits from the simulation library and the algorithms developed in WP1 (T1.1) also in port processes optimisation and shore power solutions.

Intelligent Traffic Management facilitates real-time monitoring and control of traffic flow on inland waterways to provide comprehensive situational awareness, leveraging data from various sources, i.e., Automatic Identification System (AIS) data, weather information, and traffic sensors, through advanced data analytics and predictive modelling, traffic management systems can optimize vessel routing, improve safety, reduce congestion, and enhance overall operational efficiency.

In AS2 the Intelligent IW Traffic Management developed innovations in WP2 combine the technologies and expertise developed within IW-NET for decision management and strategic planning, and are tested on the way to achieving sustainable infrastructure and optimizing traffic flow management in inland waterway transport. Further, the simulation library and algorithms developed in WP1 further enhance AS2 by providing the foundation for traffic flow simulation models. These models allow for the evaluation of different management and planning strategies to address infrastructure bottlenecks, optimize vessel scheduling, and improve overall traffic flow. By simulating different scenarios and analysing the results, stakeholders can make informed decisions and identify cost-effective measures to enhance navigability and increase the capacity of the waterway.

Within AS2, the two specific use cases, AS2A and AS2B, demonstrate the practical application and importance of the technologies developed in WP2 and WP1.

- AS2A focuses on Collaborative IWT Management and Planning. It addresses the challenges posed by infrastructure bottlenecks, particularly narrow fairway sections that restrict the passage of large vessels. Through the development of a traffic flow simulation model, data gathering on real-life conditions, and the implementation of suitable traffic flow management strategies, AS2A aims to improve the efficiency and effectiveness of vessel operations in the corridor. The technologies developed in WP2, such as the traffic flow simulation model and the analysis of AIS data, enable stakeholders to identify optimal vessel routes, assess the impact of different management strategies, and make data-driven decisions to enhance navigability and traffic flow.
- AS2B focuses on the digitalization of collaboration and coordination processes between inland vessels and local authorities. Currently, paper-based, verbal, and email communications are prevalent, leading to inefficiencies and delays. Through the Digital Service Center Application and the integration of IoT technology for shore power processes, AS2B aims to streamline port call procedures, enhance communication between vessels and authorities, and improve environmental sustainability. The technologies developed in WP2, including the Digital Service Center Application and the IoT-enabled shore power solution, enable efficient data exchange, real-time visibility, and environmental monitoring. By replacing manual processes with digital

solutions, AS2B facilitates seamless collaboration, reduces administrative burdens, and promotes sustainable practices in inland waterway transport.

The gist of the Application Scenarios AS2 is to test the multifaceted technologies developed within IW-NET WP2 and WP1, using them to enhance the efficiency and effectiveness of traffic management and planning in IWT. By leveraging real-time data, advanced analytics, and simulation models, IW Transport Services Providers collaborating with Supply Chain and mainly Infrastructure Stakeholders can optimize vessel routing, minimize delays, and improve their overall operational performance. Strategy and operations planning using the simulation scenarios enables better utilization of existing infrastructure by identifying bottlenecks, evaluating alternative management strategies, and implementing cost-effective measures. This contributes to increased capacity, reduced congestion, and improved navigability in the waterway network. Thirdly, the shore power solutions matched with user friendly applications and advanced digitalization technologies promote sustainability in inland waterway transport by optimizing energy consumption, reducing emissions, and minimizing the ecological impact of vessel operations.

Hence the progress and the success of AS2 implementation will ensure a comprehensive and integrated approach to traffic management, exploiting the developed simulation capabilities to support intelligent traffic management and to achieve efficient, safe, and sustainable inland waterway transport systems.

4.1 Application Scenario 2A (AS2A), Collaborative IWT management and planning

AS2A (see AS2A Summary Card, Figure 12) aims to ensure the efficient and sustainable utilization of the waterway network, facilitating the smooth movement of goods and contributing to the overall competitiveness of inland waterway transport. The primary objective is to enable sustainable infrastructure and traffic flow management on inland waterways, specifically addressing the hinterland connections of Bremerhaven via the River Weser and the Mittelland Canal in Northern Germany. This application scenario is closely linked to WP2 (Intelligent Traffic Management) and specifically to tasks T2.2, T2.3, and T2.4.

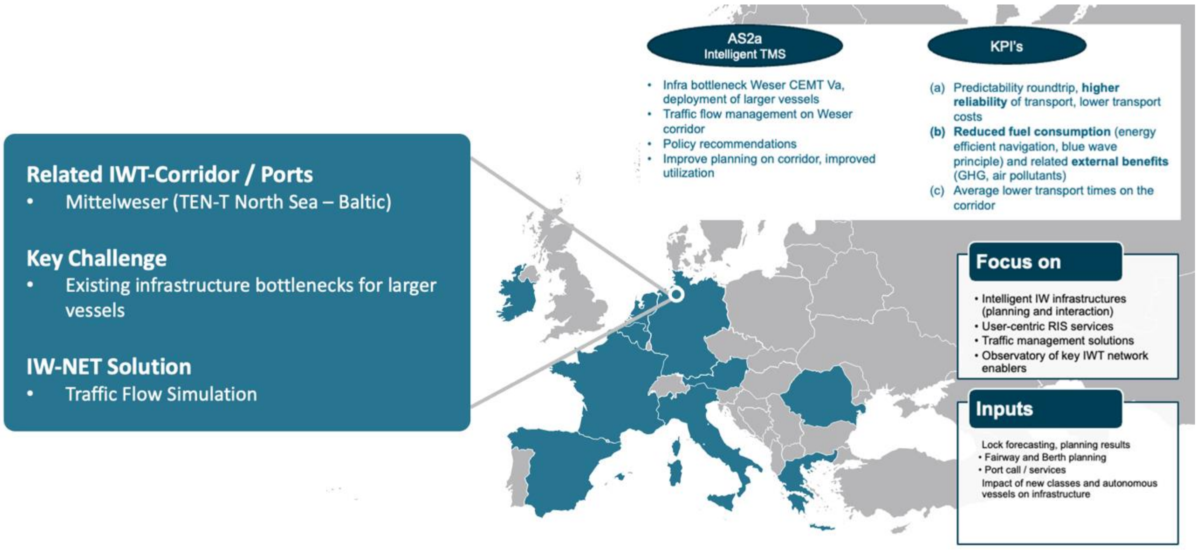

Figure 12: AS2A Summary Card

One of the main challenges in this corridor is the limited efficiency of large vessels, such as Großmotorgüterschiffe (GMS – CEMT class Va), due to infrastructure bottlenecks and narrow fairway sections. To overcome these challenges, AS2A leverages traffic flow simulation and management solutions developed in WP2, based on models and libraries developed in the task T1.1.

The initial setup of AS2A involves the development of a traffic flow simulation model within WP2. This model aims to evaluate the effectiveness of different management and planning strategies to improve the corridor's navigability for large vessels. By simulating various scenarios, the model helps identify cost-effective measures to optimize traffic flow and address infrastructure constraints and to help understand the current state of a waterway network, evaluating traffic regulations, and assessing the impact of potential interventions. Data are collected for the traffic flow simulation model from the German Federal Waterway and Shipping Administration, providing information on the characteristics of the inland waterway network, including traffic-regulated areas, locks, and berths. The current traffic regulation rules and processes are elicited by engaged experts. To gather fleet characteristics and traffic flow patterns, AIS (Automatic Identification System) analysis is conducted, utilizing data sourced from the corridor over a representative timespan.

Concept proving focuses on the development of traffic flow management strategies that are validated using simulation modelling approaches. This process involves reviewing scientific literature and studying ongoing pilot projects in similar corridors to identify best practices and innovative approaches to traffic management. By implementing simulation components and evaluating their applicability, the concept proving phase demonstrates the potential effectiveness of the identified strategies.

The ongoing evolution of AS2A involves calibrating the simulation models to the specific conditions of the Mittelweser region. This calibration ensures that the models accurately represent the characteristics and challenges of the waterway. Subsequently, simulation experiments are conducted to test alternative traffic flow management strategies identified in the previous phase. These experiments help assess the effectiveness and feasibility of different interventions, providing valuable insights for decision-making. The technologies developed within IW-NET WP2, including the traffic flow simulation model and associated methodologies, are essential for improving the collaborative management and planning of inland waterway transport. They provide a data-driven approach to optimize traffic flow, identify infrastructure improvements, and enhance the navigability of the corridor. By leveraging advanced digitalization technologies.

4.2 Application Scenario 2B (AS2B), Shore power and berth planning

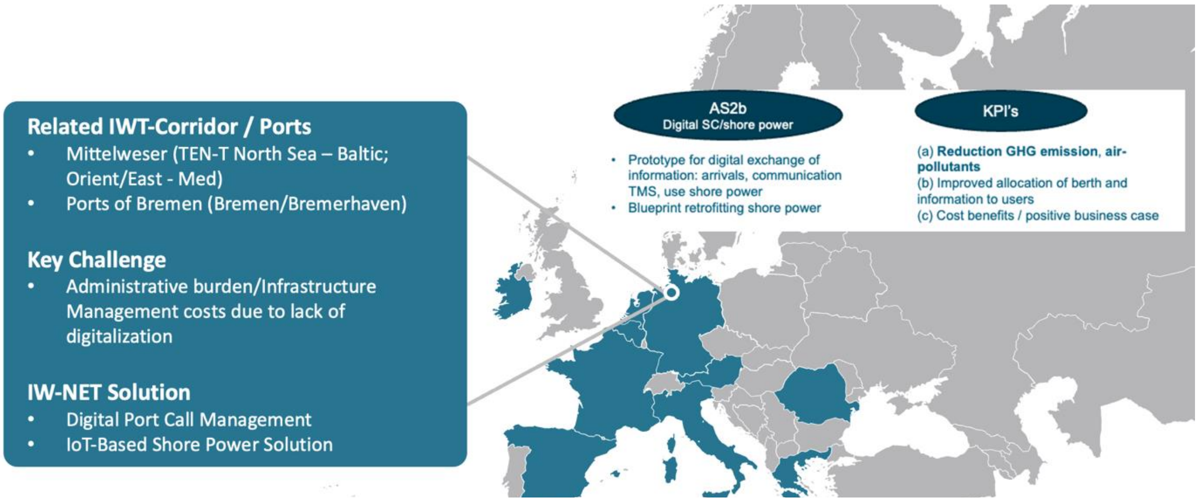

Figure 13: AS2B Summary Card

By embracing advanced digitalization technologies, AS2B (see summary card, Figure 13) aims to revolutionize the way inland vessels interact with local authorities, improving communication, coordination, and overall operational efficiency. These technologies enable seamless information exchange, reduce administration overloads, and support the transition towards a more sustainable and environmentally friendly inland waterway transport system. This application scenario addresses the challenges posed by traditional communication methods prevalent in the industry. The goal is to introduce advanced digitalization technologies developed within IW-NET WP2 (Intelligent Traffic Management) to enable efficient and real-time visibility, improve operational processes, and enhance environmental sustainability.

The ongoing focus of AS2B is to enhance collaboration and coordination between inland vessels and local authorities by leveraging advanced digitalization technologies. By replacing paper-based, verbal, and email communications with digital solutions, AS2B aims to streamline communication processes and improve overall operational efficiency. A key step in this process is the initial setup, which identifies the existing limitations in communication and collaboration between inland vessels and local authorities. This assessment enables the development of best practices and approaches that can overcome these challenges and drive efficient and timely collaboration.

Requirements gathering for the Digital Service Center Application involves a comprehensive approach that includes stakeholder mapping, expert interviews, focus group discussions, and online surveys. By involving key industry stakeholders and gathering their input, the requirements gathering process ensures that the developed digitalization technologies meet the needs and expectations of the industry. During the concept proving phase, the functional concepts for the Digital Service Center Application are communicated and discussed with AS2B stakeholders. This process ensures that the envisioned workflow and functionality align with the stakeholders' requirements. Visual mock-ups and prototypes are developed to showcase the potential benefits and usability of the digitalization technologies.

AS2B involves the implementation of system interfaces with operational systems, such as port traffic management and billing systems. This integration ensures seamless data exchange and efficient integration of the digitalization technologies into existing infrastructure. Real-world testing of the IW-NET shore power solution at selected berths within the port of Bremen evaluates its effectiveness in reducing emissions and improving environmental sustainability.

The technologies developed within IW-NET WP2, including the Digital Service Center Application and the IoT-enabled shore power solution, play a critical role in digitalizing and streamlining collaboration and coordination processes in inland waterway transport. These technologies enhance efficiency, accuracy, and real-time visibility, ultimately improving the overall operational effectiveness of the industry. Additionally, they contribute to environmental sustainability by promoting the use of shore power and reducing the ecological impact of inland waterway transport operations.

4.3 AS2 relevance with the MSEs of IW-NET

The technologies developed within IW-NET WP2, including traffic flow simulation models, Digital Service Center application, and IoT-enabled shore power solutions, are tested in AS2A and AS2B.

- In AS2A, the impact and outputs of the MSEs can be demonstrated through the optimization of traffic flow, reduction in congestion, and improvement in vessel routing efficiency. Key performance indicators (KPIs) such as vessel turnaround time, waiting times at locks, and overall traffic flow performance can be used to measure the success of AS2A.
- In AS2B, the impact and outputs of the MSEs can be demonstrated through the streamlining of communication and collaboration processes, reduction in administrative efforts, and increased environmental sustainability using shore power. KPIs such as the number of digital

interactions between inland vessels and local authorities, reduction in paperwork, and energy savings from shore power utilization can be used to measure the success of AS2B.

Overall, both AS2A and AS2B contribute to the objectives of enhancing the efficiency, reliability, and sustainability of inland waterway transport. The application and testing of advanced digitalization technologies and data-driven optimization techniques enable collaborative management and planning of IWT services, optimize traffic flow, improve operational performance, and promote sustainable best practices in IWT. The relevance of the application scenarios and the IW-NET MSEs is provided by their mapping in Table 5.

Table 5: MSEs for AS2

AS2A - Collaborative IWT management and Planning	
MSE2: *Data-driven IWT operations optimization in corridors.*	Leverages data-driven optimization techniques, including traffic flow simulation models developed in WP2, to improve traffic management and planning in the corridor. The impact can be measured by evaluating the reduction in congestion, improvement in vessel routing efficiency, and overall operational performance of IWT services.
MSE4: *Collaborative IWT planning, including infrastructure operations.*	Focuses on collaborative planning and management of inland waterway transport, specifically addressing infrastructure bottlenecks in the corridor. The impact can be measured by assessing the effectiveness of collaborative planning strategies in optimizing traffic flow, addressing infrastructure constraints, and improving navigability.
AS2B - Shore power and berth planning	
MSE5: *Collaborative berth planning and shore power.*	Aims to streamline port call procedures and enhance collaboration between inland vessels and local authorities through the implementation of digitalization technologies developed in WP2. The impact can be measured by evaluating the reduction in administration, improved communication, and coordination, and increased environmental sustainability using shore power.

4.4 AS2 value contribution on the Unique Value Points (UVPs) of IW-NET

AS2A focuses on collaborative IWT management and planning, utilizing traffic flow simulation models and advanced data analytics. By optimizing vessel routing, improving efficiency, and addressing infrastructure bottlenecks, AS2A enhances navigability and traffic flow. It contributes to UPVs by optimizing IWT services, promoting collaboration, streamlining planning processes, improving infrastructure maintenance, supporting strategic decision-making, and enabling advanced analysis. AS2A's contributions lead to enhanced operational efficiency, sustainability, collaboration, and decision-making in the IWT infrastructure administration.

AS2B utilizes advanced digitalization technologies to improve communication and coordination between inland vessels and local authorities. By streamlining port call procedures, enhancing collaboration, and promoting environmental sustainability, AS2B achieves multiple benefits. The Digital Service Center Application and IoT-enabled shore power solutions facilitate efficient data exchange, real-time visibility, and environmental monitoring, effectively reducing administrative costs, improving operational efficiency, and minimizing the ecological impact of IWT.

AS2 contributes to the formation and value creation of the UVPs of IW-NET as follows (see Table 6):

Table 6: AS2 Unique Value Points (UPVs)

Unique Value Points	AS2A	AS2B
UVP1: Support modal shift to Inland Waterways Transport (IWT) by optimizing services and operations, improving real-time visibility, and enabling efficient tracking.	AS2A supports UVP1 by optimizing IWT services and operations in synchromodal transport networks, evaluating the accuracy, reliability, and responsiveness of IWT processes, and assessing the effectiveness of advanced decision support, improved visibility, and enhanced tracking.	AS2B supports UVP1 by improving the accuracy and reliability of IWT processes, evaluating the impact of event-based notifications, enriched information distribution, and real-time tracking, and assessing the effectiveness of improved visibility, precise scheduling, and delivery optimization.
UVP2: Enhance collaboration in IWT services by facilitating secure and seamless information exchange, improving the management of residual IWT capacity, and providing real-time barge transportation options.	AS2A supports UVP2 by promoting collaboration among stakeholders involved in IW transportation services, evaluating the effectiveness of information sharing, optimization of IWT resources, and improved collaboration through the IW-NET Open Architecture Solution for Port Call Procedures.	AS2B supports UVP2 by improving collaboration in IW transportation services, making real-time information available to SMEs through services hub and API gateways, and assessing the impact of dynamic optimization of IWT resources, improved service availability information, and standards based real-time data exchange.
UVP3: Streamline and optimize IWT planning processes with the help of advanced algorithms and big data analytics. This also includes enabling real-time traffic information and using IoT for automation.	AS2A supports UVP3 by streamlining and optimizing IWT planning processes by enabling improved estimations, predictions, and algorithm-based decision-making, and assessing the impact of streamlined planning on operational performance, network resilience, and cost efficiency	AS2B supports UVP3 by improving IWT planning processes, creating innovative port call procedures and workflows, based on real-time traffic information, integration between decision levels, enhancing planning processes on port resources usage improving responsiveness, and agility.
UVP5: Improve infrastructure maintenance and ports operations, reducing costs and CO2 footprint through improved maintenance of infrastructure and advanced shore services management.	AS2A supports UVP5 by improving infrastructure maintenance and port operations evaluating the effectiveness of upgraded locks management, scheduling notifications, and shore services management, and assessing their impact on infrastructure reliability, resource utilization, and CO2 footprint reduction.	AS2B supports UVP5 by streamlining port call procedures, evaluating the Digital Service Center Application and IoT-enabled shore power solutions, and assessing their impact on administrative costs and operational efficiency, and ecological impact reduction in IWT.
UVP7: Improve strategic decisions in IWT by simplifying the modal shift reasoning process, accelerating strategy planning, and creating a best practices portfolio. This includes the development of	AS2A supports UVP7 by supporting strategic decision-making in IWT, evaluating simulation and modelling capabilities, best practices, and comprehensive impact assessments, and providing insights for strategy planning and stakeholder engagement.	AS2B supports UVP7 by improving strategic decision-making in IWT, evaluating the effects of fully deploying shore power solutions, and assessing the impact on infrastructures and the development of EU IWT

EU IWT roadmaps and roadmaps for policy impact.		roadmaps for greening port solutions.
UVP8: Reduce GHG emissions by ensuring IWT operations follow the latest standards in the Global Logistics Emissions Council, the GLEC framework, and the forthcoming ISO process.	AS2A supports UVP8 by addressing the reduction of greenhouse gas (GHG) emissions in synchro-modal IWT, evaluating the links to global emissions standards, data interoperability, and environmental impact reduction measures, and assessing the effectiveness of measures implemented to reduce GHG emissions and align with sustainability goals.	AS2B supports UVP8 by addressing the reduction of greenhouse gas (GHG) emissions and assessing the effectiveness of measures taken to control emissions, and to promote environmental sustainability.
UVP9: Make advanced big data analytics accessible to IWT SMEs by providing an open-source big data analytics environment and a library of recipes.	AS2A supports UVP9 by exploring the accessibility of advanced big data sources from AIS, for planning and optimization services in IWT, evaluating the models simulation library, and assessing their effectiveness enabling data-driven insights for planning and optimization in IWT infrastructures.	AS2B supports UVP9 by enabling advanced planning and decision-making processes through data-driven approaches.

4.5 AS2 User Stories

Using the Agile approach based on User Stories, which are implemented via the AS activities, there follows a set of initial and high-level user stories is provided for the Application Scenario AS2A.

	AS2A User Stories
Who: *What:* *Why:*	As a transportation planner, I want access to traffic flow simulation models and advanced data analytics, to optimize vessel routing and improve efficiency in the Northern Germany region.
Who: *What:* *Why:*	As a port operator, I want to identify and address infrastructure bottlenecks along the River Weser to enhance navigability and traffic flow.
Who: *What:* *Why:*	As a vessel operator, I want real-time information on waterway conditions, such as water levels and traffic congestion, make informed decisions regarding vessel routing and scheduling.
Who: *What:* *Why:*	As a logistics coordinator, I want to optimize the utilization of inland waterway transport by leveraging advanced traffic management systems and predictive analytics, to optimise the IWT.
Who: *What:* *Why:*	As a transportation manager, I want to improve the competitiveness and sustainability of inland waterway transport in the region by implementing innovative solutions for vessel management and planning, for sustainability.
Who: *What:* *Why:*	As a government agency, I want to support the development of efficient and reliable inland waterway transport by providing access to accurate traffic information and infrastructure improvement plan, for efficient and reliable IWT.
Who: *What:* *Why:*	As a logistics service provider, I want to optimize vessel routing and improve overall supply chain efficiency, to improve my operations.
Who: *What:* *Why:*	As a sustainability manager, I want to quantify the environmental benefits achieved through optimized vessel routing and reduced congestion on the waterways, to improve sustainability of IWT.

In the following a set of high-level user stories is provided for the Application Scenario AS2B.

	AS2B User Stories
Who: *What:* *Why:*	As a port authority, I want to streamline communication and coordination processes with inland vessels and local authorities through digital solutions, to reduce administrative burdens and improving operational efficiency.
Who: *What:* *Why:*	As an inland vessel operator, I want to have a seamless and standardized process for port calls, including berthing planning, scheduling, and documentation, to optimize turnaround time and minimize delays.
Who: *What:* *Why:*	As an environmental sustainability officer, I want to monitor and track the ecological impact of inland waterway transport in real-time, enabling proactive measures, to reduce emissions and promote sustainable practices.
Who: *What:* *Why:*	As a logistics coordinator, I want access to real-time information on berth availability, shore power availability, and other port services, to optimize vessel scheduling and minimize waiting times.
Who: *What:* *Why:*	As a regulatory authority, I want to ensure compliance with environmental regulations and shore power usage by providing digital solutions for monitoring and reporting, to be compliant.
Who: *What:* *Why:*	As a vessel skipper, I want to have easy access to information and instructions related to shore power connections, safety protocols, and other port procedures through a digital platform, to improve operational efficiency and safety.
Who: *What:* *Why:*	As a port operator, I want to collaborate with other stakeholders to promote the use of shore power and other sustainable practices in inland waterway transport, to reduce the overall carbon footprint.
Who: *What:* *Why:*	As a maintenance manager, I want to use tools to monitor and optimize shore power infrastructure, to ensure its availability and reliability for inland vessels.

4.6 AS2 KPIs

In the following a set of high level KPIs related to the Application scenarios AS2A and AS2B is listed in Table 7. The table brings some indicative KPIs while the actual KPIs for the Application Scenarios A2 will be defined in deliverable D4.3.

Table 7: KPIs AS2

AS2A - Collaborative IWT management and planning indicative KPIs	
Improvement in navigability and traffic flow.	Measures the enhancement in navigability and traffic flow, reflecting improved waterway conditions and reduced congestion.
Reduction in infrastructure bottlenecks through optimized vessel routing.	Measures the decrease in infrastructure bottlenecks through optimized routing of vessels, indicating improved efficiency in the transportation network.
Increase in efficiency and reliability of IWT services.	Measures the improvement in efficiency and reliability of IWT services, indicating enhanced service quality and performance.
Percentage increase in the utilization of IWT resources through collaborative management and planning.	Measures the percentage increase in the utilization of IWT resources resulting from collaborative management and planning efforts, indicating improved resource allocation and utilization.

Reduction in logistics costs achieved through traffic flow simulation models and advanced data analytics.	Measures the cost savings achieved in logistics through the utilization of traffic flow simulation models and advanced data analytics, indicating improved operational efficiency.
AS2B - Shore power and berth planning indicative KPIs	
Reduction in administrative burdens through the implementation of digital solutions.	Measures the decrease in administrative burdens through the adoption of digital solutions, indicating streamlined processes and reduced paperwork.
Increase in operational efficiency achieved by streamlining port call procedures.	Measures the improvement in operational efficiency achieved by streamlining port call procedures, indicating reduced waiting times and increased productivity.
Reduction in ecological impact through the adoption of shore power solutions.	Measures the decrease in ecological impact through the adoption of shore power solutions, indicating a shift toward more environmentally friendly operations.
Improvement in collaboration and communication between inland vessels and local authorities.	Measures the enhancement in collaboration and communication between inland vessels and local authorities, indicating improved coordination and cooperation.

5 AS3 - innovative IW fleet including autonomous vessels for urban distribution

Overall, AS3 aims to revolutionize urban distribution by leveraging innovative vessel technologies and advanced digitalization solutions. The integration of automation, connectivity, and accurate navigation systems improves operational efficiency, safety, and environmental sustainability in inland waterway transport. By combining vessel advancements, IoT solutions, and GNSS services, AS3 contributes to the transformation of urban waterway transport systems into intelligent, efficient, and eco-friendly modes of freight and passenger transportation.

The technologies developed within IW-NET WP3 play a crucial role in realizing the vision of autonomous vessels for urban distribution. These technologies encompass automation, connectivity, and advanced sensing capabilities. By integrating these technologies, the autonomous vessels demonstrate improved operational efficiency, reduced environmental impact, and enhanced safety in urban waterway transport.

AS3 focuses on the introduction and testing of innovative inland waterway (IW) fleet technologies, including autonomous vessels, for urban distribution within the IW-NET Living Lab. It aims to increase the efficiency, competitiveness, and reliability of IWT through advanced vessels that are of small size so that they can adapt to the urban environment and introduce many innovations towards automation, locational awareness, improved connectivity, navigability, and optimized capacity to meet the industry's requirements. The value proposition of AS3 lies in the integration of these innovative technologies into a fleet of vessels that are intelligent, interconnected, and capable of interacting with their environment. By analyzing the potential benefits of these technologies when implemented on a fleet rather than a single vessel, AS3 aims to provide insights into their economic and ecological impact and their potential to optimize urban distribution.

AS3 tests the IoT solutions developed in WP1 by NGS. These solutions enable a high level of automation and provide real-time data monitoring. The IoT system is configured to monitor various parameters, such as predictive maintenance, water levels, thermal imaging, and position. This monitoring enhances operational efficiency, safety, and decision-making processes.

The success of AS3 is evaluated through key performance indicators (KPIs) such as capacity load, tonnage moved per distance, trips to difficult-to-reach areas, reduction in greenhouse gas emissions, connectivity speed, and loading/unloading times. These KPIs assess the efficiency, effectiveness, and environmental impact of the innovative vessel technologies and their integration into urban distribution operations. AS3 involves two use cases:

AS3A involves all steps in vessel construction, including the study of the propulsion system, selection of engines, batteries, control equipment, and sensors. The automation model is refined, and testing is conducted in the designated test areas. Additional tests are performed with the KUL research vessel and the newly developed barge, allowing for data collection, integration, and analysis.

AS3B focuses on the assessment of the benefits of using GNSS services for highly automated vessels. The implementation and testing of advanced navigation functionalities, such as guidance assistance, bridge height warning systems, and automatic lock entry, are performed on existing vessels in the digital testbed on the Spree-Oder Waterway in Berlin. The functionalities are also tested on the newly developed barge and the KUL boats in Ghent.

The concept proving phase of AS3B involves the implementation and testing of enhanced localization techniques using autonomous navigation technologies and services. The utilization of the SAPOS PPP/RTK Service, including Galileo satellites, enables accurate positioning and navigation. The integrity monitoring station is set up within the testbed, and measurement campaigns are conducted to evaluate real-time positioning using the PPP/RTK correction service.

Iterations of AS3B include the evaluation of the benefits of autonomous navigation technologies, implementation tests of the GALILEO positioning system, integration of the DLR Positioning system into the KUL Sensor Box and testing of GNSS integrity messages onboard the vessels. The aim is to enhance navigation accuracy, assess the effects of signal outages, and enable seamless data sharing through developments in WP1.

The success criteria for AS3B include achieving a high level of automation and safety, enhancing barge navigation technologies through improved location awareness, and enabling the safe operation of innovative IW vessels. The evaluation focuses on the effectiveness of the positioning systems, the performance of autonomous functionalities, and the mitigation of signal outages.

5.1 Application Scenario 3A (AS3A), Autonomous vessels for urban distribution

AS3A (see summary card, Figure 14) focuses on the introduction and testing of innovative autonomous vessels for urban distribution within the IW-NET Living Lab. The application scenario aims to leverage advanced technologies developed within IW-NET WP3 (Innovative Vessel Technologies) to optimize urban transport operations, increase efficiency, and reduce environmental impact.

Figure 14: AS3A Summary Card

The key objective of AS3A is to develop and test a new type of barge that integrates cutting-edge technologies for inland waterway transport. These technologies include automation, locational awareness, connectivity, and optimized capacity. The introduction of autonomous vessels brings numerous benefits, such as improved vessel characteristics, efficient last-mile delivery, optimized logistics flows, enhanced cargo visibility, and seamless connectivity with the surrounding infrastructure.

KU Leuven (KUL) introduces two vessels for testing and experimentation: the Cogge and the Maverick. The Cogge serves as an unmanned, automated, and remotely controlled test vessel, while the Maverick is designed to reach an automation maturity level that allows for unmanned operation. Both vessels incorporate advanced sensor systems, such as the Sensor Box, which provides navigational and perception information. The Shore Control Centre, operated by KUL, orchestrates the KU Leuven fleet, ensuring seamless coordination and control.

OHL focuses on the development and testing of a new barge design that incorporates the innovations developed in WP3. The barge is specifically designed for urban waterways, such as those in the city of Ghent. It is a flat-ship model made of aluminium, with a capacity of 20 tons, with a size of approx. 15 m x 4 m and a draft of 0.4 m is a perfect fit to the shallow waters and the low bridges of Gent. The barge is equipped with a fully electric engine, powered by a 20 KW battery pack, making it CO2 neutral. Its shallow draft and compact size enable efficient navigation in the city's waterways.

The concept proving phase involves the development of use cases that demonstrate the capabilities of the innovative vessel technologies. These use cases include the demonstration of the zero-emission barge's characteristics, efficient last-mile delivery, optimization of logistics flows in urban scenarios, cargo visibility through sensor deployment, and vessel autonomy solutions. These use cases validate the effectiveness of the technologies in real-world scenarios and showcase their potential benefits. Therefore, to showcase the capabilities of the autonomous vessels, several concept proving use cases (UC) have been formalized:

UC1 – Boat construction and testing specific small vessel characteristics and features: The Zero Emission Barge board and Infrastructure for loading and unloading in the City of Ghent. This use case demonstrates the vessel's characteristics, such as balance, speed, emergency handling, safety features, range, and propulsion. It also showcases the efficient loading and unloading of cargo, highlighting the requirements for efficient last-mile delivery.

UC2 - Optimizing Logistics flows in Urban scenarios: This use case focuses on the distribution of construction materials to areas with restricted access. By utilizing a zero-emission vessel, recommendations can be generated regarding infrastructure requirements, environmental safety, and improvements in quality of life. The use of autonomous vessels streamlines logistics flows, making them more efficient and sustainable.

UC3 - Vessel autonomy solutions for cargo visibility: This use case involves deploying various sensors, including vibration, temperature, CO2, HCl, ultrasonic, distance measurement, thermal cameras, and chemical sensors. These sensors are connected via a cloud service to track and trace cargo, providing real-time visibility and ensuring cargo safety. The KUL sensor box on the experimental boat facilitates the integration of sensors and enhances overall vessel autonomy.

UC4 - Vessel Autonomous solutions and technologies and platooning: This use case involves deploying a sensor box on the shoreside to communicate with automated barges, such as the Cogge and the Urban Boat, to receive environmental data. This information is utilized to co-determine control decisions, particularly for close encounter manoeuvres. Sailing trajectories are tested with and without the sensor box, platooning is examined using Lidar technology, and automated head-on passing between the urban barge and Cogge is performed, adhering to COLREG[7] rule 14. Also integrates developments of WP3 to include enhancements through satellite-assisted navigation.

The successful implementation of AS3A requires the development of a comprehensive study on vessel design, propulsion systems, engine selection, battery capacity, control equipment, and sensors. The vessels are designed to operate emission-free, utilizing electric engines and advanced battery packs to ensure sustainability. Additionally, models of automation are elaborated in partnership with KUL and DLR, ensuring the vessels can operate autonomously and safely.

Testing and experimentation take place in designated testbed areas, allowing for the validation of vessel characteristics, the performance of cargo handling operations, and the assessment of navigation

[7] Convention on the International Regulations for Preventing Collisions at Sea, 1972, https://www.imo.org/en/About/Conventions/Pages/COLREG.aspx

and control systems. Throughout the testing phase, data collection, integration, and analysis are conducted to evaluate the vessels' functionality, operational efficiency, and environmental benefits.

By emphasizing the importance of autonomous vessel technologies and their practical applications, AS3A contributes to the advancement of urban waterway transport. The integration of these technologies enables efficient and sustainable distribution of goods, optimization of logistics flows, and enhanced cargo visibility. AS3A sets the foundation for future developments in autonomous vessel technologies, providing valuable insights and best practices for stakeholders in the inland waterway transport industry.

5.2 Application Scenario 3B (AS3B), Advanced use of GALILEO services for navigation

This application scenario, within the IW-NET Living Lab, aims to harness the capabilities of satellite-based positioning systems to enhance vessel navigation, improve safety, and optimize operations. The technologies developed within IW-NET WP3, specifically in innovative vessel technologies, are instrumental in the successful implementation of AS3B (see summary card, Figure 15). These technologies integrate satellite-based services, such as Galileo, to enable high-precision positioning and navigation capabilities. AS3B tests the results of WP3, focusing on the assessment and utilization of the developed satellite-based services, for navigation in inland waterway transport.

Figure 15: AS3B Summary Card

The importance of satellite-based services for navigation is high and cannot be overstated. With the increasing complexity of waterway networks and the need for precise positioning, Galileo-based services offer advanced functionalities that significantly contribute to the efficiency and safety of inland waterway transport.

The successful conclusion of AS3B will contribute to advancing the field of satellite-based navigation for inland waterway transport. By leveraging Galileo and other satellite-based services, inland vessels can benefit from improved positioning accuracy, enhanced safety, and optimized navigation. The integration of these technologies promotes efficient and reliable transport operations while ensuring compliance with regulations and standards.

The assessment of satellite-based navigation technologies within AS3B involves evaluating the benefits of satellite-based navigation technologies for critical scenarios and expanding the testing scope. This includes integrating the Satellite Based positioning systems into test vessels, evaluating the usability of GNSS integrity messages, and exploring data streaming and sharing capabilities of the IW-NET platform solutions.

To this end, AS3B provides valuable insights, best practices, and guidelines for stakeholders in the inland waterway transport industry. It enables the industry to make informed decisions regarding the adoption and utilization of advanced navigation systems.

Within AS3B, the following use case has been identified to demonstrate the benefits and applications of satellite-based navigation services:

UC5 - Advanced barge navigation technologies through enhanced location awareness: This use case focuses on the implementation and testing of enhanced localization techniques using autonomous navigation technologies and Galileo positioning system services. The use of satellite-assisted navigation enables precise control and manoeuvring, contributing to safe and efficient operations. The goal is to evaluate the benefits of high-precision positioning for autonomous vessels compared to standard code-based positioning. The evaluation includes assessing the impact of high-precision positioning on autonomous vessel steering, analysing the effects of satellite signal outages, and exploring communication channels for transmitting GNSS correction and integrity monitoring data.

Testing includes scenarios such as close encounter manoeuvres and automated head-on passing, ensuring compliance with relevant regulations. This involves scenarios in waterway locks and near bridges, where accurate satellite navigation systems play a vital role in ensuring safe and precise navigation. The effects of satellite signal reception outages, particularly under bridges, are analysed, and mitigation strategies are developed to minimize their impact on the positioning system.

Further, this use case will extend the “UC4 - Vessel Autonomous solutions and technologies and platooning”, introducing accuracy enhancements via Satellite-assisted navigation. This includes the integration of the DLR positioning system into the KUL sensor box, ensuring seamless communication and data exchange. The integration of Galileo-based services, including PPP/RTK correction, will enhance the positioning accuracy of the vessels in this Application Scenario.

The initial setup of AS3B involves working closely with the Spree-Oder Waterway (SOW) digital testbed in the vicinity of Berlin. Existing vessels in the testbed are equipped with enhanced location awareness technologies to assess the benefits of satellite-based navigation services. The use of Galileo and PPP/RTK correction services enhances positioning accuracy, enabling safe navigation in critical scenarios such as waterway locks and bridge crossings.

5.3 AS3 relevance with the MSEs of IW-NET

The technologies developed within IW-NET WP3, including automation and autonomy systems, connectivity and communication solutions, and satellite-based navigation technologies, are extensively being tested in AS3A and AS3B.

- In AS3A, the impact and outputs of the MSEs are demonstrated through the successful deployment and testing of the developed vessels for urban distribution. Key performance indicators (KPIs) such as efficiency of last-mile delivery, reduction in greenhouse gas emissions, cargo visibility, and improvement in logistics flows can be used to measure the success of AS3A.

- In AS3B, the impact and outputs of the MSEs can be demonstrated through the integration and utilization of advanced satellite-based navigation technologies. KPIs such as improvement in vessel positioning accuracy, enhancement in safety during critical scenarios, and optimization of navigation operations can be used to measure the success of AS3B.

Overall, both AS3A and AS3B contribute to the objectives of providing IWT driven innovations for urban distribution, enhancing operational efficiency, improving safety, and promoting environmental sustainability in IWT. The application and testing of innovative vessel technologies, connectivity solutions, and satellite-based navigation systems provide valuable insights, best practices, and guidelines for stakeholders in the industry, facilitating the adoption and utilization of advanced technologies of IWT in the urban environments (Table 8).

Table 8: MSEs for AS3

AS3A - Autonomous Vessels for Urban Distribution	
MSE1: *Automation and autonomy in IWT.*	Focuses on the introduction and testing of innovative autonomous vessels for urban distribution. The integration of automation and technologies developed within IW-NET WP3 enables improved operational efficiency, optimized logistics flows, enhanced cargo visibility, and seamless connectivity with the surrounding infrastructure. The impact can be demonstrated by measuring the efficiency of last-mile delivery, reduction in greenhouse gas emissions, optimization of logistics flows, and improvement in cargo visibility.
MSE3: *Improved connectivity and communication systems for IWT.*	Emphasizes the importance of advanced connectivity and communication systems in enabling efficient and seamless operations of autonomous vessels. The integration of IoT solutions and sensor systems developed in WP1 enables real-time data monitoring, coordination, and control of the vessels within the urban waterway network. The impact can be demonstrated by measuring the reduction in administrative burdens, improved vessel coordination, and enhanced safety through real-time data exchange.
MSE6: *Enhanced location accuracy through Satellite-Based Augmentation Systems (SBAS) navigation.*	Enhanced location accuracy through SBAS navigation contributes to the safe and efficient operation of autonomous vessels for urban distribution. Accurate positioning is critical for precise control and manoeuvring of autonomous vessels, ensuring safety and optimized operations. The impact can be demonstrated by measuring the improvement in vessel autonomy, safety during navigation, and efficiency of urban distribution operations.
MSE7: *Innovation in IW fleet and autonomous vessels for urban distribution.*	Focuses on the introduction and testing of autonomous vessels for urban distribution. The integration of innovative vessel technologies and autonomy solutions aims to optimize urban transport operations and increase efficiency. The impact can be demonstrated by measuring the efficiency gains, reduction in emissions, optimization of last-mile delivery, and improvement in logistics flows achieved through the adoption of autonomous vessels.
AS3B - Advanced Use of GALILEO Services for Navigation	
MSE3: *Improved connectivity and communication systems for IWT.*	Utilises satellite-based positioning systems, including Galileo, to enhance vessel navigation, improve safety, and optimize operations. The integration of satellite-based navigation technologies developed within IW-NET WP3 enables high-precision positioning, accurate navigation, and compliance with regulations. The impact can be demonstrated by measuring the improvement in vessel positioning accuracy, enhanced safety in critical scenarios, and optimization of navigation operations.
MSE6: *Enhanced location accuracy through Satellite-Based Augmentation Systems (SBAS) navigation.*	Enhanced location accuracy through SBAS navigation is essential for advanced navigation functionalities and safe vessel operations. Accurate positioning enables precise control, navigation assistance, and adherence to relevant regulations. The impact can be demonstrated by measuring the improvement in vessel navigation accuracy, enhancement in safety during critical scenarios, and optimization of navigation operation.
MSE7: *Innovation in IW fleet and autonomous vessels for urban distribution.*	Contributes to advancing the field of satellite-based navigation for inland waterway transport and showcases the potential of autonomous vessels for safe and efficient operations. The impact can be demonstrated by measuring the improvement in vessel positioning accuracy, enhancement in safety during critical scenarios, and optimization of navigation operations.

5.4 AS3 value contribution on the Unique Value Points (UVPs) of IW-NET

AS3A (Autonomous vessels for urban distribution) provides valuable insights and best practices for stakeholders, introducing flexible small barges for urban distribution scenarios that incorporate automation, locational awareness, connectivity, and optimized capacity, including advancements in vessels autonomy. AS3A optimizes urban transport operations, increases efficiency, and reduces environmental impact. AS3A demonstrates the vessel's characteristics, efficient delivery, logistics flow optimization, cargo visibility, and autonomy.

AS3B (Advanced use of GALILEO services for navigation) includes the assessment and utilization of satellite-based navigation services for inland waterway transport enhancing vessel positioning accuracy, safety, and navigation efficiency. AS3B focuses on advanced navigation functionalities, such as guidance assistance, bridge height warning systems, automatic lock entry, and high-precision positioning. Key aspects of AS3B are enhanced location awareness, advanced barge navigation technologies, and the evaluation of high-precision positioning for autonomous vessels. AS3B provides valuable insights and guidelines for stakeholders in the industry, facilitating the adoption and utilization of advanced navigation systems in inland waterway transport.

AS3 contributes to the formation and value creation of the UVPs of IW-NET as follows (see Table 9):

Table 9: AS3 Unique Value Points (UPVs)

Unique Value Points	AS3A	AS3B
UVP1: Support modal shift to Inland Waterways Transport (IWT) by optimizing services and operations, improving real-time visibility, and enabling efficient tracking.	AS3A vessels can be use in urban scenarios of cities requiring small vessels, using solutions developed for AS1A, optimizing IWT services and operations through advanced solutions as platooning to sustain larger capacity flow requirements. AS3A assesses the effectiveness of available options contributing to modal shift to inland waterways.	
UVP2: Enhance collaboration in IWT services by facilitating secure and seamless information exchange, improving the management of residual IWT capacity, and providing real-time barge transportation options.	AS3A with KUL scenario optimizes IWT services and operations in automation creating a shared perception space. AS3A validates the effectiveness of technological options with the 'Cogge-Box' which allows the monitoring and interaction of the automated boat with a control centre, for real-time information exchange.	
UVP4: Advance vessel technology by promoting innovative vessel types, introducing blockchain solutions for cargo shipping, and establishing Galileo as the benchmark solution for high precision positioning in IWT.	AS3A explores autonomous vessel technology innovations and their impact on IWT services. It evaluates autonomous navigation options, and the integration of IoT solutions to improve vessel efficiency and safe navigation.	AS3B enhances navigation safety and efficiency in IWT using GALILEO satellite-based positioning systems. It assesses the impact GNSS services on navigation safety and efficiency. AS3B focuses on enhancing IW transportation services collaboration by integrating advanced GNSS services from GALILEO. It evaluates the accuracy, performance, and impact of these services on accurate positioning, safe navigation, and enhanced
UVP6: Extend IWT's value for urban logistics by applying innovative vessel designs and operation modes to improve the sustainability of urban distribution systems.	AS3A focuses on innovative vessel designs and operation modes for urban distribution. It evaluates vessel fleets, automation capabilities, and planning and booking solutions, contributing to modal shift, sustainability, and efficiency in urban logistics.	

		collaboration among IW stakeholders.
UVP7: Improve strategic decisions in IWT by simplifying the modal shift reasoning process, accelerating strategy planning, and creating a best practices portfolio. This includes the development of EU IWT roadmaps and roadmaps for policy impact.	AS3A assesses the impact of business model, process, and technology innovations on strategic decision-making for modal shift in urban scenarios and supports the development of EU IWT Roadmaps.	
UVP8: Reduce GHG emissions by ensuring IWT operations follow the latest standards in the Global Logistics Emissions Council, the GLEC framework, and the forthcoming ISO process.	AS3A reduces GHG emissions by adopting eco-friendly designs and operation modes for vessels using electric engines and in general eco-friendly fuel solutions, contributing to sustainability and environmental impact reduction in IWT.	
UVP9: Make advanced big data analytics accessible to IWT SMEs by providing an open-source big data analytics environment and a library of recipes.		

5.5 AS3 User Stories

Using the Agile approach based on User Stories, which are implemented via the AS activities, there follows a set of initial and high-level user stories is provided for the Application Scenario AS3A.

	AS3A User Stories
Who: *What:* *Why:*	As a logistics manager, I want to explore the use of innovative automated vessels solutions for urban distribution, to improve the efficiency and sustainability of last-mile deliveries in dense urban areas.
Who: *What:* *Why:*	As a barge operator, I want to leverage advanced technologies, automation, locational awareness, and optimized capacity, to optimize vessel operations, reduce costs, and improve delivery timelines.
Who: *What:* *Why:*	As a city planner, I want to assess the feasibility and impact of introducing autonomous vessels for urban distribution in terms of traffic congestion reduction, air pollution mitigation, to improve urban sustainability.
Who: *What:* *Why:*	As an environmental sustainability officer, I want to evaluate the environmental benefits of using autonomous vessels for urban distribution, such as reduced greenhouse gas emissions, noise pollution, and traffic congestion, for environmentally friendly options in urban logistics.
Who: *What:* *Why:*	As a regulatory authority, I want to establish guidelines and regulations for the safe and responsible operation of autonomous vessels in urban areas, to ensure compliance with safety standards and minimizing potential risks.

In the following a set of high-level user stories is provided for the Application Scenario AS3B.

	AS3B User Stories
Who: *What:* *Why:*	As a vessel operator, I want to utilize GNSS and Galileo services to optimize the utilization of waterway infrastructure, to reduce waiting times at locks and to improve efficiency of cargo transportation.
Who: *What:* *Why:*	As a navigation authority, I want to implement GNSS and Galileo services, to minimize the number of incidents, leading to a reduction in delays caused by waterway disruptions and an improvement in the reliability of IWT.
Who: *What:* *Why:*	As a technology provider, I want to develop innovative GNSS and Galileo-based applications that enable seamless integration and interoperability with existing navigation systems, facilitating the adoption and utilization of these technologies across the IWT sector.
Who: *What:* *Why:*	As a regulatory body, I want to monitor and evaluate the impact of implementing GNSS and Galileo services on the safety and performance of inland waterway transport, using KPIs such as reduction in incidents, improved navigation accuracy, and increased efficiency.
Who: *What:* *Why:*	As an environmental sustainability officer, I want to evaluate the potential environmental benefits of adopting GNSS and Galileo services, to improve safety and to minimize ecological impact, contributing to the overall sustainability of inland waterway transport.
Who: *What:* *Why:*	As a regulatory body, I want to establish guidelines and standards for the safe and effective use of GNSS and Galileo services in inland waterway navigation, ensuring compliance, interoperability, and the integrity of positioning data, to help interoperability and compliance in IWT.
Who: *What:* *Why:*	As an infrastructure manager, I want to utilize GNSS and Galileo services, to improve the efficiency of infrastructure maintenance and operations, such as accurate tracking of vessels, monitoring of water levels, and optimization of lock usage.
Who: *What:* *Why:*	As a vessel operator, I want to use Galileo and GNSS, to deploy solutions as platooning which will let me be more flexible in planning IWT operations.

5.6 AS3 KPIs

In the following a set of high level KPIs related to the Application scenarios AS3A and AS3B is listed in Table 10. The table brings some indicative KPIs while the actual KPIs for the Application Scenarios A2 will be defined in deliverable D4.4.

Table 10: KPIs AS3

AS3A - Autonomous Vessels for Urban Distribution indicative KPIs	
Increase in operational efficiency achieved through the introduction of innovative, highly automated vessels for urban distribution.	Measures the improvement in operational efficiency resulting from the introduction of the innovative automated vessels, indicating reduced costs and improved performance.
Reduction in environmental impact using zero-emission and electric-powered vessels.	Measures the decrease in environmental impact resulting from the use of zero-emission and electric-powered vessels, indicating improved sustainability.
Increase in cargo visibility and tracking capabilities through sensor deployment.	Measures the increase in location awareness, also cargo status visibility and tracking capabilities through the deployment of sensors.

Improvement in last-mile delivery efficiency and optimization of logistics flows.	Measures the enhancement in last-mile delivery efficiency and optimization of logistics flows, indicating improved customer service and cost-effectiveness.
AS3B - Advanced Use of GALILEO Services for Navigation indicative KPIs	
Improvement in vessel navigation accuracy and safety using GALILEO services.	Measures the enhancement in vessel navigation accuracy and safety achieved through the utilization of GALILEO services, indicating improved positioning and risk reduction.
Improved efficiency of operations in critical navigation scenarios.	Measures the decrease in delays, increase in safety and the improvement in efficiency in critical navigation scenarios, indicating better operational performance and reliability.
Increase location awareness and advanced barge navigation technologies	Measures the enhancement of location awareness and the utilization of advanced barge navigation technologies, indicating improved situational awareness and operational capabilities.
Increase in high-precision positioning adoption and integration with GALILEO.	Measures the increase in the adoption and integration of high-precision positioning technologies with GALILEO, indicating improved accuracy and precision in navigation.
Increase in the utilization of satellite-based navigation systems in inland waterway transport.	Measures the increase in the utilization of satellite-based navigation systems in inland waterway transport, indicating the growing reliance on advanced navigation technologies.

6 Conclusions

6.1 Main conclusions

This document has been produced in the context of T4.1 and it is the Application Scenarios Handbook, providing a framework for the analysis and the understanding of the Application Scenarios AS1, AS2, and AS3 of IW-NET, each application scenario featuring two main use cases. These Application Scenarios of are mapped to the project tasks T4.2, T4.3, and T4.4, while each application scenario produces feedback on developments in work-packages WP1, WP2 and WP3. The applications scenarios under consideration are:

- AS1A - Application and testing of advanced digitalization technologies: Applies advanced digitalization technologies for efficiency, providing full track and trace based on the GS1 EPCIS standard, with IoT for the cold chain and Blockchain. The real-time tracking supports synchro-modal operations and is optimised using the Revenue Management methodology.
- AS1B - Data-Driven navigability in uncertain water: Leverages data-driven optimization to address the challenges of variable navigability in uncertain water conditions. The specific focus is placed on the Danube, with the aim of optimizing barge operations via the exploitation of data about river water levels also designs barges that are optimized for Danube navigability.
- AS2A - Collaborative IWT management and Planning: Ensures the efficient utilization of the waterway network, facilitating sustainable infrastructure and traffic flow, specifically addressing the hinterland connections of Bremerhaven via the River Weser and the Mittelland Canal in Northern Germany.
- AS2B - Shore power and berth planning: Optimises the use of shore power and berth planning in IWT services. It aims to improve the efficiency and sustainability of these services through advanced planning and management techniques.
- AS3A - Autonomous vessels for urban distribution: Explores automation of vessels for urban distribution, improving the efficiency of urban logistics through the use of innovative vessel designs with specific barge characteristics, suited for low bridges and navigating in densely populated urban areas.
- AS3B - Advanced use of GALILEO services for navigation: Leverages advanced GALILEO services for navigation in IWT services, improving the accuracy and efficiency of navigation, thereby enhancing the overall performance and safety of IWT services.

For each Application Scenario execution, an agile methodology is proposed; based on SCRUM and KANBAN, while for AS2 the themes of the agile approach have been based on the Design Thinking approach. The Application Scenarios Framework involves the mapping of the Modal Shift Enablers (MSEs) of IW-NET which provides a valuable context for analysis of the innovations tested. A further mapping has been made to the Unique Value Points (UVPs) of IW-NET, so to let identify quick-wins and best practices. The Application Scenarios analysis also includes a set of top-level user stories and the KPIs. These concepts will be exploited in the validation and evaluation steps of the Application Scenarios.

Important to mention that in task T4.1, the IW-NET Digitalisation Architecture aggregating outcomes of WP1, has been set up and deployed in the cloud to enable the connection and the exchange of information for the solutions deployed by the Application Scenarios. The progress of this activity was based on an agile CI/CD (continuous integration and continuous deployment) scheme, while the architecture components have been produced using Open-Source solutions and are published in Github.

6.2 Next Steps

This document is the basis of the analysis step to be performed in Task 4.5 and deliverable D4.5 for the verification of the Application Scenarios.

The results collected from the application scenarios form the foundation for driving capacity building initiatives and help shaping the IWT roadmaps and the pathways towards exploitation and commercialization of IW-NET solutions in WP5.

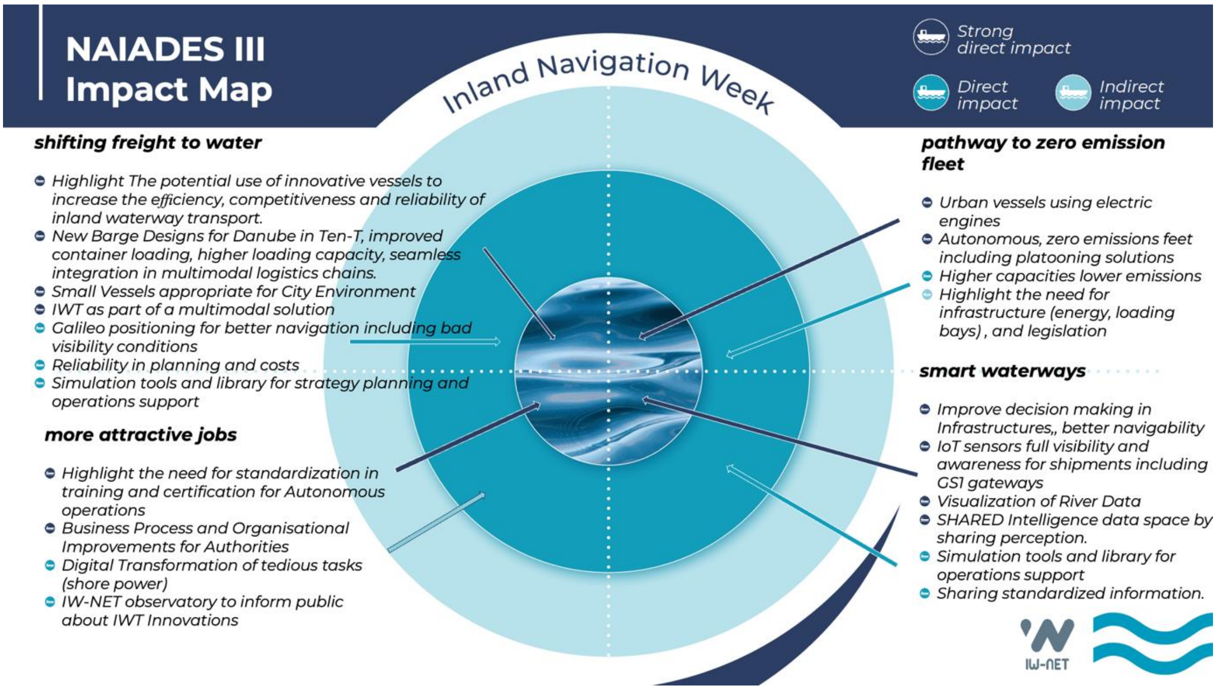

Figure 16: IW-NET and impact to NAIADES III

Further it is worth mentioning that the execution of the IW-NET Application Scenarios which form the field for testing innovations developed by the main Pillars of the project, i.e., the (a) Digitalisation innovations, (b) the Infrastructure Improvements and (c) the Innovative Vessel technologies map well with the NAIADES III Impact Map, as shown in Figure 16.

And the last is one of the main lessons learned, is the importance of interacting via WP5 with the other EU projects for IWT Automation and Resilience solutions and be aligned to main initiatives such as DIWA[8] [6], PLATINA 3[9], and NAIADES[10] [8], and the Application Scenarios of IW-NET offer a good basis to engage, and to interact with the main stakeholders of IWT.

8 https://www.masterplandiwa.eu
9 https://platina3.eu
10 https://www.inlandwaterwaytransport.eu/promoting-inland-waterway-transport-through-the-naiades-iii-action-plan/

7 References

1. SCRUM: https://www.scrum.org
2. KANBAN: https://kanbanguides.org
3. ARCHIMATE 3.2: https://pubs.opengroup.org/architecture/archimate32-doc/index.html
4. D1.5 and D1.6: "Big Data analytics linked with IWT corridor data hub", Versions 1 and 2
5. D1.7: "Synchro-modality booking and execution management dashboard and architecture extensions, dynamic optimisation", Version 1
6. DIWA masterplan: https://www.masterplandiwa.eu
7. PLATINA 3: https://platina3.eu
8. NAIADES III Action Plan: https://www.inlandwaterwaytransport.eu/promoting-inland-waterway-transport-through-the-naiades-iii-action-plan/

Annex I: Archimate Methodology Elements

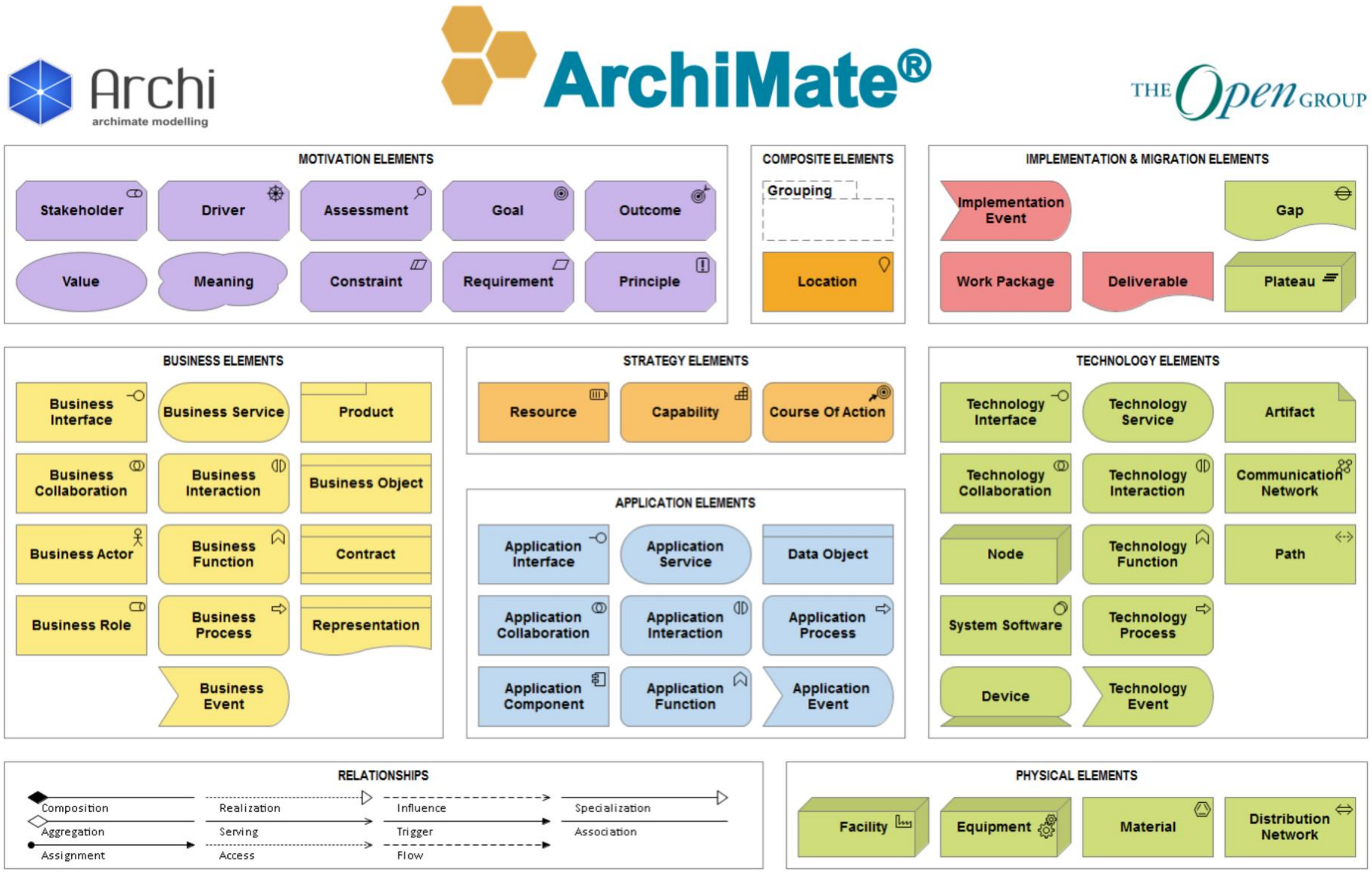

Figure 17: Archimate methodology Elements