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Ploto

D2.2

Definition of the requirements, use cases and system specifications final version

Project name

Deployment and assessment of predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes

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Quality Control

	Name	Organisation	Date
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Version	Date	Author	Summary of changes
0.1	22/03/2023	RISA	Table of Contents, First draft of document
0.2	06/06/3023	RISA	Draft document (methodology, user requirements and architecture)
0.3	17/07/3023	RISA	Draft document (methodology, user requirements and architecture, etc.)
0.4	09/08/2023	RISA	Complete draft version for internal review
0.5	25/08/2023	RISA, ULIEGE, BME	Internal review updates
1.0	31/08/2023	RISA	Final submitted version

1.1	19/06/2024	INTRA, AFDJ, UDG, RRT	Updated version incorporating the changes in the sector/area for the PLOTO Use Case A: Danube Area, including the waterways and inland ports, following the PLOTO 2nd GA Amendment

Legal Disclaimer

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List of abbreviations and acronyms

Abbreviation	Meaning
AIS	Automatic Identification System
CC	Climate Change
CI/CD	Continuous Integration/ Continuous Delivery or Deployment
COP	Common Operational Picture
DF	Data Fusion
DSS	Decision Support System
Dx.x	Deliverable x.x
EC	European Commission
ELOHA	Ecological Limits of Hydrologic Alteration
EU	European Union
FR	Functional Requirements
GA	Grant Agreement
GVA	Gross Value Added
IMS	Incident Management System
IS	Information System
IR	Interface Requirements
ISO	International Standardisation Organisation
IWAT	IWW Assessment Tool
IWW	Inland WaterWays
KPI	Key Performance Indicator
mFDA	Multi-sensor Flaw and Degradation Assessment
MT	Ministry of Transport
Mx	Month x
NFR	Non-Functional Requirements
OS	Operating System
PR	Process Requirements
RIS	River Information System

sFDA	Satellite Flaw and Degradation Assessment
STO	Scientific and Technical Objective
Tx.x	Task x.x
UAS	Unmanned Aircraft System
UI	User Interface
UID	Unique Identification
UR	Usability Requirements
WP	Work Package

Executive Summary

PLOTO project aims at increasing the resilience of the Inland WaterWays (IWW) infrastructures and the connected hinterland-infrastructures, thus ensuring reliable network availability under unfavourable conditions, such as extreme weather, accidents and other kind of hazards. PLOTO's main target is to combine downscaled Climate Change (CC) scenarios (applied to IWW infrastructures) with simulation tools and actual data, so as to provide the relevant authorities and their operators with an integrated tool able to support more effective management of their infrastructures at strategic and operational levels. The PLOTO integrated platform and its tools will be validated in three case studies in Belgium, Romania, and Hungary. The aim of this report is to:

- refine the end-user requirements (Section 3), as presented in D2.1 (T2.2);
- produce a detailed specification of PLOTO system requirements (Section 4, T2.2);
- describe the PLOTO platform's modules as part of the high-level architectural specification (Section 5, T2.3) and;
- define the scenarios (Section 6) together with the relevant set of Key Performance Indicators (KPIs, Section 7) (T2.2).

1. Introduction

1.1 Project information

The project entitled **"Deployment and assessment of predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against climate change and other extremes (PLOTO)"** aims at increasing the resilience of the IWW and the connected hinterland infrastructures, especially under adverse conditions, such as extreme weather, accidents and other kinds of hazards. In doing this, downscaled climate change scenarios will be combined with simulation tools and actual data, to provide operators an integrated tool able to support more effective management of their infrastructures at strategic and operational levels.

PLOTO project consists in the deployment and assessment of predictive modelling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against climate change and other extremes. An integrated tool is set up to allow relevant authorities to improve the efficiency of their infrastructures management. This tool is a combination of downscaled climate change scenarios with simulation tools and actual data. Six complementary avenues will be considered to achieve this integrated tool that will support relevant authorities and their operators for more effective management:

- Measure and use high-resolution modelling data for the determination and assessment of the climatic risk of the selected transport infrastructures and associated expected damages.
- Use existing data from various sources with new types of sensor-generated data (computer vision) to feed the used simulator.
- Utilise tailored weather forecasts (combining seamlessly all available data sources) for specific hot spots, providing real-time early warnings with corresponding impact assessment.
- Develop improved multi-temporal, multi-sensor UAV- and satellite-based observations with robust spectral analysis, computer vision and machine learning-based assessment for diverse transport infrastructures.
- Design and implement an integrated resilience assessment platform environment as an innovative planning tool that will permit a quantitative resilience assessment through an end-to-end simulation environment, running "what-if" impact/risk/resilience assessment scenarios. The effects of adaptation measures can be investigated by changing the hazard, exposure and vulnerability input parameters.
- Design and implement a Common Operational Picture (COP), including an enhanced visualisation interface and an Incident Management System (IMS).

The PLOTO integrated platform and its tools will be validated in three case studies in Belgium, Romania and Hungary.

1.2 Purpose of the deliverable

Deliverable 2.2 "Definition of the requirements, use cases and system specifications – final version" is one of the three deliverables of WP2 and is related to Task 2.2 "Specification of system requirements, Use Cases, Scenarios Definition and KPIs" and Task 2.3 "Design of the overall system architecture". In the preliminary version of this deliverable (D2.1, M6) the following information was presented: (a) literature review on issues related to technical, regulatory and financial aspects that shall be considered for the development of the PLOTO integrated system (T2.1); (b) end-user needs (T2.1); (c) initial list of end-user requirements (T2.2); (d) preliminary description of PLOTO platform's modules (T2.2) and; (e) initial information of the use cases and scenarios that will be used to validate the PLOTO platform in WP7 (T2.2).

In this second Deliverable, the end-user requirements are refined and are matched with system requirements, the PLOTO platform's modules and data are defined, the PLOTO system architectural specification is described and the scenarios together with the relevant set of KPIs are presented.

Attainment of the objectives and explanation of deviations

This Deliverable is related to PLOTO Milestone 3 "Final version of setting up the Use Cases and System Requirements through the End-Users Workshops". The specific objective has been achieved in full and as scheduled.

1.3 Intended audience

Deliverable 2.2 is public, it will be openly available to all stakeholders, such as public authorities, IWW and other hinterland infrastructure owners and operators, researchers and technology providers, as well as decision and policy makers interested in a report presenting Inland Waterways end-user needs and requirements towards the design and development of a system that improves the resilience of IWW against Climate change and other extremes. This Deliverable is also of great interest to all PLOTO partners as it analyses end-user needs and requirements, as well as the system modules, architecture, KPIs and use cases/scenarios.

1.4 Structure of the deliverable and its relation with other work packages/deliverables

The Deliverable is structured as follows:

Section 1. Describes PLOTO's aim as well as this document's purpose, intended audience and structure.

Section 2. Describes the methodology followed in this deliverable.

Section 3. Presents PLOTO end-users' requirements.

Section 4. Describes PLOTO system requirements.

Section 5. Analyses PLOTO system high-level architecture.

Section 6. Presents use cases and scenarios.

Section 7. Describes PLOTO Key Performance Indicators.

Section 8. Concludes the Deliverable by summarising the main outcomes and referring to future work.

2. Methodology

This Deliverable aims to refine the end-user requirements, produce a detailed specification of PLOTO system requirements, PLOTO platform's modules, as well as present the high-level system architecture and define the use cases together with the relevant set of KPIs. In the following paragraphs, the specific methodology (Figure 1) that was used to meet this deliverable's aim, time plan, and milestones, will be described.

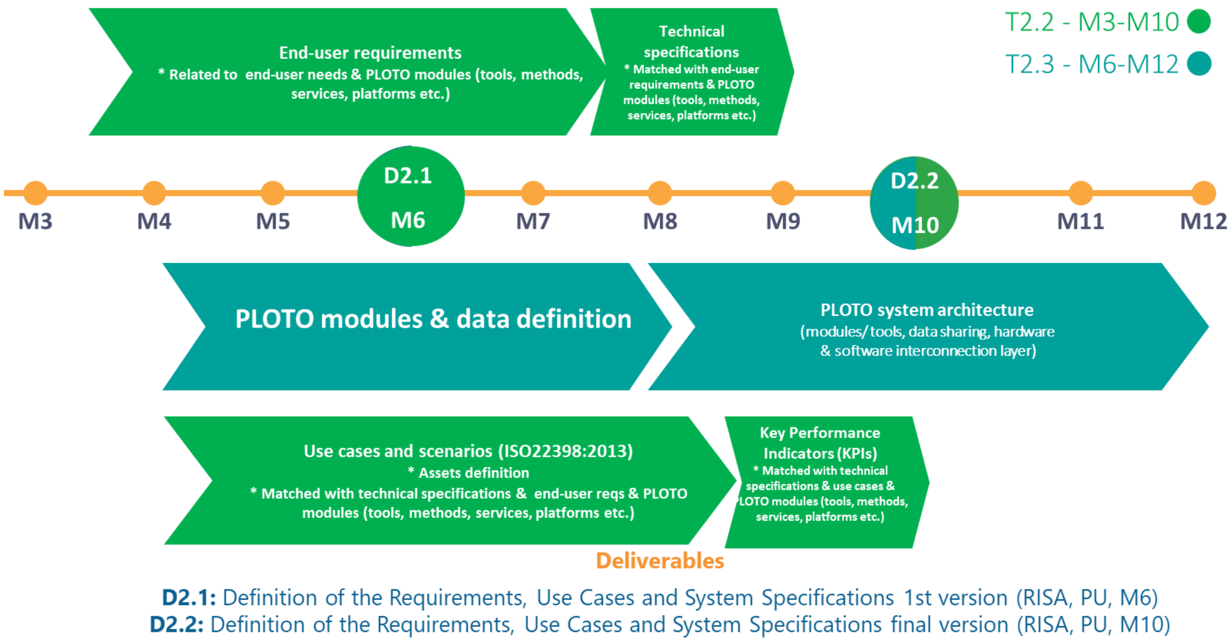

Figure 1: Deliverable's methodology

More specifically, a bi-weekly and ad-hoc meeting were organised, where all WP2 partners participated actively. During these meetings the partners discussed the progress of the work, as well as clarified relevant to the Task issues and risks. More specifically, at the beginning of T2.2, a timeplan was defined and agreed between partners and the initial aim was the refinement of the end-users requirements (as defined in D2.1), as well as the definition of the PLOTO modules and data. Based on the aforementioned, technical partners and providers worked on the system requirements definition (using the relevant template for information collections); which were matched with the end-users requirements and continued with the PLOTO architectural definition. Finally, all partners cooperated to specify the use cases and scenarios, as well as the Key Performance Indicators that will be used during the validation of PLOTO integrated platform and tools in three case studies in Belgium, Romania and Hungary.

3. End-users' requirements

The requirements list, as presented in D2.1 (M6), has been updated, as the project evolved. So, in this Chapter, the final list of end-users' requirements (per requirement type), as identified by end-users and partners, is presented.

3.1 Functional requirements

The updated list of functional requirements of the PLOTO platform is displayed in Table 1.

Table 1: PLOTO Functional Requirements

UID	FR-1
Requirement Category	Weather situation
Requirement Name	Wind
Requirement Description	Providing current wind data (15 mins) (at the point of the weather station)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-2
Requirement Category	Weather situation
Requirement Name	Water level
Requirement Description	Providing current water level (once per day)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-3
Requirement Category	Weather situation
Requirement Name	Fog
Requirement Description	Providing current fog situation (15 mins) (at the point of the weather station)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-4
Requirement Category	Weather situation
Requirement Name	Precipitation

Requirement Description	Providing current precipitation data (once per 3 hrs) (everywhere in the pilot site)
Priority	Should-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases C

UID	FR-5
Requirement Category	Weather situation
Requirement Name	Precipitation
Requirement Description	Providing current precipitation data (15 mins) (at the point of the weather station)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases B

UID	FR-6
Requirement Category	Weather situation
Requirement Name	Temperature
Requirement Description	Providing current air temperature data (15 mins) (at the point of the weather station)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-7
Requirement Category	Traffic situation
Requirement Name	Traffic
Requirement Description	Providing vessel position data (TBD)
Priority	Should-have
Relative WP	WP6
Relative Module	WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-8
Requirement Category	Shipment
Requirement Name	Traffic situation
Requirement Description	Providing characteristics of the vessel and cargo (event-based)
Priority	Should-have
Relative WP	WP6
Relative Module	WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-9
Requirement Category	Wind
Requirement Name	Wind forecast
Requirement Description	Direction and strength of wind must be known in advance on certain locations for a predefined time interval and updated with a predefined frequency. (update: 3 hrs , resolution: 15 minutes)
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-10
Requirement Category	Water level
Requirement Name	Water-level forecast
Requirement Description	Water level must be known in advance on certain locations, in a predefined time interval, and updated with a predefined frequency. (update: once per day, resolution: 24 hrs)
Priority	Must-have
Relative WP	WP4, WP6
Relative Module	WP4 and WP6 modules
Relative Use Case	All

UID	FR-11
Requirement Category	Arrival time
Requirement Name	Predicting arrival time
Requirement Description	Knowing the parameters (vessel parameters, cargo parameters, departure location and time, arrival location) of a navigation task, the arrival time could be predicted with high reliability. (update: hourly; resolution: minute)
Priority	Could-have
Relative WP	WP6
Relative Module	WP6 modules
Relative Use Case	Use Case B

UID	FR-12
Requirement Category	IWW section and floodplain flooding
Requirement Name	Modelling water level and flood arrival time in fairway and floodplain for specified dike breaching scenario
Requirement Description	Location, water level, time and duration of flood must be modelled for various pre-defined scenarios
Priority	Must-have
Relative WP	WP3, WP4, WP6
Relative Module	WP3, WP4, WP6 modules
Relative Use Case	Use Case C

UID	FR-13
Requirement Category	Fog warning
Requirement Name	Fog warning forecast
Requirement Description	Provision of fog warning. (update: 3 hrs)
Priority	Should-have
Relative WP	WP3, WP6
Relative Module	WP3 modules
Relative Use Case	Use Cases B

UID	FR-14
Requirement Category	Precipitation
Requirement Name	Precipitation forecast
Requirement Description	Type and volume of precipitation should be known in advance on certain locations for a predefined time interval and updated with a predefined frequency. (update: 3 hrs)
Priority	Should-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases B

UID	FR-15
Requirement Category	Temperature
Requirement Name	Temperature forecast
Requirement Description	Temperature should be known in advance on certain locations for a predefined time interval and updated with a predefined frequency. (update: 3 hrs)
Priority	Should-have
Relative WP	WP3, WP6
Relative Module	WP3 and WP6 modules
Relative Use Case	Use Cases A, B

UID	FR-16
Requirement Category	Users authorisation
Requirement Name	Users authorisation
Requirement Description	Only authorised users must access the system. Unauthorized access must be declined.
Priority	Must-have
Relative WP	TBD RISA / STWS– WP6
Relative Module	WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-17
Requirement Category	Map classification
Requirement Name	Map classification
Requirement Description	Diverse strategies must be followed for different Tiers.

Priority	Must-have
Relative WP	WP4, WP6
Relative Module	WP4 and WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-18
Requirement Category	Peril monitoring
Requirement Name	Peril monitoring
Requirement Description	PLOTO system should monitor specific perils (e.g., flood, draught, storm)
Priority	Must-have
Relative WP	WP3, WP4, WP5, WP6
Relative Module	WP3 and WP4 modules
Relative Use Case	Use Cases A, B, C

UID	FR-19
Requirement Category	User Management
Requirement Name	User Management
Requirement Description	Administrators must be able to manage users' accounts.
Priority	Must-have
Relative WP	WP6
Relative Module	WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-20
Requirement Category	Users Roles Management
Requirement Name	Users Roles Management
Requirement Description	All users must have access to the role they are matched with.
Priority	Must-have
Relative WP	WP6
Relative Module	WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-21
Requirement Category	Damage maps
Requirement Name	Damage maps
Requirement Description	PLOTO system must provide fast assessment damage maps (satellite, ground control station and UAV- based).
Priority	Must-have
Relative WP	WP5, WP6
Relative Module	WP5 and WP6 modules
Relative Use Case	Use Cases A, B, C

UID	FR-22
Requirement Category	Hazards assessment

Requirement Name	Hazard maps
Requirement Description	Definition of hazard maps from various fused data sources and streams
Priority	Could-have
Relative WP	WP4
Relative Module	T4.1
Relative Use Case	Use case A,B,C

UID	FR-23
Requirement Category	Display and map hazard modelling outcomes
Requirement Name	Map
Requirement Description	User should receive simulation results, hazard (e.g., inundation extent and depth) and vulnerability information as well as IWW elements
Priority	Must-have
Relative WP	WP4
Relative Module	IWAT
Relative Use Case	Use Cases A, B, C

UID	FR-24
Requirement Category	Several related information services are available on one user interface.
Requirement Name	Common interface
Requirement Description	Users should receive a comprehensive 'picture' about all circumstances that may influence their operational decisions, in an easily accessible and understandable way.
Priority	Should-have
Relative WP	WP6
Relative Module	COP
Relative Use Case	Use Cases A, B, C

UID	FR-25
Requirement Category	Interactive map with all relevant information.
Requirement Name	Map
Requirement Description	Users should receive a comprehensive 'picture' with location data and visualization about all circumstances, which may influence their operational decisions, in an easily accessible and understandable way especially providing location-based information services with alerts and notifications. Different information types may be visualized on different layers of the map. E.g., wind layer, temperature layer, water level layer.
Priority	Could-have
Relative WP	WP6
Relative Module	COP
Relative Use Case	Use Cases A, B, C

UID	FR-26
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	The user interface design shall make the user's interaction with the system as simple and efficient as possible in terms of accomplishing their goals.
Priority	Must-have
Relative WP	WP6
Relative Module	COP
Relative Use Case	Use Cases A, B, C

UID	FR-27
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	Data must be represented in high resolution for critical, important and high impact (based on the end-users needs and input) assets, buildings and structures that will be represented in the DT.
Priority	Must-have
Relative WP	WP6
Relative Module	DT
Relative Use Case	Use Cases A, B, C

UID	FR-28
Requirement Category	predictions about the water levels
Requirement Name	Water Level Forecast
Requirement Description	Predictions about the impact of climate change (changing water levels) shall be taken into account in the GNS process as they may lead to new possibilities to improve navigation on waterways and the waterway management.
Priority	Must-have
Relative WP	WP3, WP4, WP6
Relative Module	WP3, WP4, WP6 modules
Relative Use Case	Use Cases A, B, C

3.2 Non-functional requirements

In Table 2, the updated list of non-functional requirements of PLOTO platform are presented.

Table 2: PLOTO Non-Functional Requirements

UID	NFR-1
Requirement Category	Security
Requirement Name	Secure communication
Requirement Description	The system should ensure secure communication, data transactions and storage.
Priority	Must-have

Relative WP	WP6, WP7
Relative Module	Middleware
Relative Use Case	Use Cases A, B, C

UID	NFR-2
Requirement Category	Privacy
Requirement Name	Pseudonymisation mechanism
Requirement Description	The system should apply proper pseudonymisation mechanisms to ensure data protection and privacy.
Priority	Could-have
Relative WP	WP6, WP7
Relative Module	All modules
Relative Use Case	Use Cases A, B, C

UID	NFR-3
Requirement Category	Data storage
Requirement Name	Data storage
Requirement Description	The system should store all data-metadata needed.
Priority	Should-have
Relative WP	WP6
Relative Module	Middleware
Relative Use Case	Use Cases A, B, C

UID	NFR-4
Requirement Category	Weather Stations data
Requirement Name	Weather Stations data
Requirement Description	Weather Stations data must be in a commonly accepted format.
Priority	Must-have
Relative WP	WP3, WP6
Relative Module	WP3 modules, Middleware
Relative Use Case	Use Cases A,B,C

UID	NFR-5
Requirement Category	Models' output
Requirement Name	Models' format
Requirement Description	Models' output format should be in a commonly accepted format and resolution (e.g., shapefile, geoTiff, csv)
Priority	Must-have
Relative WP	WP3, WP4
Relative Module	WP3 and WP4 modules
Relative Use Case	Use Cases A,B,C

UID	NFR-6
Requirement Category	Integration
Requirement Name	Software integration framework

Requirement Description	An appropriate software integration framework must be put in place for PLOTO, to make sure that all the components of the integrated platform are easily and safely integrated and tested before getting deployed at the pilots environment.
Priority	Must-have
Relative WP	WP6, WP7
Relative Module	WP6 modules, CI/CD system (T7.1)
Relative Use Case	Use Cases A, B,C

UID	NFR-7
Requirement Category	Integration
Requirement Name	Software portability
Requirement Description	The PLOTO software components should be packaged in a way that ensures their portability and deployment across different hosting environments (e.g., development/testing environment vs pilots' execution environment)
Priority	Must-have
Relative WP	WP6, WP7
Relative Module	WP6 modules, CI/CD system (T7.1)
Relative Use Case	Use Cases A, B,C

3.3 Interface requirements

The updated list of interface requirements of the PLOTO platform is displayed in Table 3.

Table 3: PLOTO Interface Requirements

UID	IR-1
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	COP will be generated by assimilating data from all PLOTO information (climate data and services, fused and raw data from all kinds of sensors (ground, space and UAVs), simulation results, vulnerability information, as well as all IWW elements, and metadata in terms of GIS information layers and depicted in an advanced 3D visualization environment
Priority	Must-have
Relative WP	WP6
Relative Module	COP
Relative Use Case	Use Cases A, B, C

UID	IR-2
Requirement Category	User Interface
Requirement Name	User Interface

Requirement Description	COP must provide a common operational picture, enhance situational awareness and support the decision-making of operators.
Priority	Must-have
Relative WP	WP6
Relative Module	COP; DSS
Relative Use Case	Use Cases A,B

UID	IR-3
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	PLOTO system must demonstrate IWW operators' seamless operations during responding to crisis situations.
Priority	Must-have
Relative WP	WP6
Relative Module	IWAT
Relative Use Case	Use Cases A,B

UID	IR-4
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	PLOTO system must demonstrate the standard response procedures for every hazard and incident type will be integrated into the IMS as workflow of proposed actions or proposed resources to be used, enabling operators to make the proper decisions in due time.
Priority	Must-have
Relative WP	WP6
Relative Module	IMS
Relative Use Case	Use Cases A,B

UID	IR-5
Requirement Category	Interfaces
Requirement Name	Weather station
Requirement Description	A new weather station will be installed.
Priority	Must-have
Relative WP	WP6
Relative Module	Middleware
Relative Use Case	Use case A

UID	IR-6
Requirement Category	Interfaces
Requirement Name	Satellite interface

Requirement Description	Satellite interface
Priority	Must-have
Relative WP	WP6
Relative Module	WP6
Relative Use Case	Use case A, B, C

UID	IR-7
Requirement Category	Interfaces
Requirement Name	Weather station
Requirement Description	2 new weather stations will be installed and integrated. 1 existing sensor will be integrated.
Priority	Must-have
Relative WP	WP6
Relative Module	Middleware
Relative Use Case	Use case B

UID	IR-8
Requirement Category	User Interface
Requirement Name	User Interface
Requirement Description	Hazard and damage assessment component need to compile the historic profiles of water levels of river streams and output them in a standardised data format.
Priority	Must-have
Relative WP	WP6
Relative Module	COP
Relative Use Case	Use Cases A, B, C

3.4 Usability requirements

Table 4 lists the usability requirements of the PLOTO platform.

Table 4: PLOTO Usability Requirements

UID	UR-1
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	Tasks shall be easily accomplished.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-2
Requirement Category	Efficiency

Requirement Name	Efficiency
Requirement Description	Tasks shall be accomplished quickly.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-3
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	Tasks shall be accomplished with few or no user errors.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-4
Requirement Category	Efficiency
Requirement Name	Efficiency
Requirement Description	The user shall be able to achieve the expected goals.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-5
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be useful.
Priority	Should-have
Owner	BME
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-6
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be reliable.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-7

Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall work accurately.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-8
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be understandable.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-9
Requirement Category	Effectiveness
Requirement Name	Effectiveness
Requirement Description	The System shall be an improvement compared to similar systems.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-10
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system shall be easy to use.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-11
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system shall be simple to use.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-12
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The user shall feel comfortable using the system.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-13
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The user shall recover easily and quickly whenever making a mistake.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-14
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The information (such as on-screen messages and other documentation) provided with this system shall be clear.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-15
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	It shall be easy for the user to find the information needed.
Priority	Should-have
Relative WP	All Technical WPs
Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

UID	UR-16
Requirement Category	Satisfaction
Requirement Name	User satisfaction
Requirement Description	The system should have user-friendly interfaces that will be easy to use without prior experience
Priority	Should-have
Relative WP	All Technical WPs

Relative Module	All PLOTO modules
Relative Use Case	Use Cases A, B, C

3.5 Process requirements

The process requirements of the PLOTO platform are displayed in Table 5.

Table 5: PLOTO Process Requirements

UID	PR-1
Requirement Category	Law/Regulation
Requirement Name	Regulation (EU) No 546/2014 (EU, 2014)
Requirement Description	The system shall be compliant with Regulation (EU) No 546/2014.
Priority	Could-have
Relative WP	All Technical WPs
Relative Module	All modules
Relative Use Case	Use Cases A,B

UID	PR-2
Requirement Category	Law/Regulation
Requirement Name	Directive 2005/44/EC on harmonised RIS (EU, 2005)
Requirement Description	The system shall comply with Directive 2005/44/EC on harmonised RIS.
Priority	Could-have
Relative WP	All Technical WPs
Relative Module	All modules
Relative Use Case	Use Cases A,B

UID	PR-3
Requirement Category	Law/Regulation
Requirement Name	Regulation (EC) No 414/2007 (EU, 2007)
Requirement Description	The system shall be compliant with Regulation (EC) No 414/2007.
Priority	Could-have
Relative WP	All Technical WPs
Relative Module	All modules
Relative Use Case	Use Cases A,B

UID	PR-4
Requirement Category	Law/Regulation
Requirement Name	Regulation (EU) 974/2018 (EU, 2018)
Requirement Description	The system shall be compliant with Regulation (EU) 2018/974.
Priority	Could-have
Relative WP	All Technical WPs
Relative Module	All modules

Relative Use Case	Use Cases A,B

UID	PR-5
Requirement Category	Law/Regulation
Requirement Name	Floods Directive (2007/60/EC) (EU, 2007)
Requirement Description	The system shall be compliant with the Floods Directive (2007/60/EC)
Priority	Could-have
Relative WP	All Technical WPs
Relative Module	All modules
Relative Use Case	Use Cases B, C

UID	PR-6
Requirement Category	Law/Regulation
Requirement Name	UAV's regulation of EU compliance
Requirement Description	The UAV operation should be compliant with the EU wide regulations: 2019/947 and 2019/945 and their amendments: 2020/639, 2020/1058 and 2020/746
Priority	Must have
Relative WP	WP5
Relative Module	Ground control station
Relative Use Case	Use Case A

UID	PR-7
Requirement Category	Law/Regulation
Requirement Name	UAV's regulation of EU compliance
Requirement Description	The UAV operation should be compliant with the EU wide regulations: 2019/947 and 2019/945 and their amendments: 2020/639, 2020/1058 and 2020/746
Priority	Must have
Relative WP	WP5
Relative Module	Ground control station
Relative Use Case	Use Case B

4. System requirements

Having defined the end-users requirements (Section 3), technical partners/providers as well as end users identified system requirements and matched them with the users' requirements (Table 6). The system requirements might get updated, as the project evolves and gets more mature.

Table 6: Description of PLOTO requirements, their relative WP and responsible partner(s)

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
1	Data shall be provided in a commonly accepted format.	WP3, WP6	WP3 and WP6 modules	FR-1, FR-2, FR-3, FR-4, FR-5, FR-6, FR-7, FR-8, FR-13, FR-14, FR-15	WP4 and WP6 partners
2	Display the water level on certain locations and in a predefined time interval in the IWAT. Water level is to be forecasted using the developed ML tools combined with data from sensors (where installed) and updated once per day.	WP4, WP6	WP4 and WP6 modules	FR-10	WP4 partners, STWS
3	PLOTO system should monitor perils using sensors where installed.	WP3, WP4, WP6	WP3, WP4 and WP6 modules	FR-18	AUTH, NTUA
4	Data acquired should be available in the middleware and accessible by the rest of the WP5 modules.	WP5, WP6	WP5 and WP6 modules	PR-6, PR-7	WP5 partners, RISA
5	Data shall be provided in a commonly accepted format.	WP4, WP6	WP4 and WP6 modules	FR-10	NTUA
6	Discharge and water level to be forecasted using the developed ML tools see FR-10) may also be generated for climate change scenarios by forcing the ML algorithm with climate projection data.	WP3, WP4, WP6	WP3, WP4, WP6 modules	FR-28	AUTH, NTUA

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
7	For predefined locations of dike breaching and hydrological scenario inflow discharge, the hydraulic model will deliver computed estimates of water level evolution and inundation extent in floodplain with propagation time.	WP3, WP4, WP6	WP3, WP4, WP6 modules	FR-12	AUTH, NTUA
8	Critical assets at risk should be modeled in detail to assess their vulnerability. To assess vulnerability, non-critical assets and hinterland infrastructure should be modeled using a surrogate, reduced-order, or generic models.	WP4, WP6	WP4 and WP6 modules	FR-17	NTUA
9	Create and display hazard maps for earthquakes using OpenQuake engine. Create and display hazard maps for flooding using ML algorithms.	WP4	T4.1	FR-22	Uliege
10	Multi-Hazard Vulnerability Modules should provide the data/output to the middleware in a commonly accepted format.	WP3, WP4	WP3 and WP4 modules	NFR-5	AUTH, NTUA
11	Sensor data shall be presented on the IWAT.	WP3, WP6	COP	FR-1, FR-2, FR-3, FR-4, FR-5, FR-6, FR-18, FR-21, IR-1, IR-2	STWS
12	Information about the traffic situation shall be presented on the IWAT.	WP6	COP	FR-7, FR-8, IR-1, IR-2	STWS
13	Forecast data (calculated by other PLOTO components) shall be presented on the IWAT.	WP6	COP, DSS	FR-9, FR-10, FR-13, FR-14, FR-15, IR-1, IR-2	STWS
14	Predictions regarding the vessel navigation info shall be presented on the IWAT. These	WP6	COP, DSS	FR-11, IR-1, IR-2	STWS

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
	predictions shall be calculated by the other PLOTO components and shall be presented on the IWAT.				
15	UAV and satellite data shall be presented to the COP.	WP6	COP, DSS	FR-21, IR-1, IR-2	STWS
16	Fused data shall be presented to the COP.	WP6	COP, DSS	IR-1, IR-2	STWS
17	COP shall be able to present to the users an overview of the current situation.	WP6	COP, DSS	FR-24, FR-25, IR-1, IR-2	STWS
18	Information will be depicted to users using specific icons, colors, and graphs per type of information (COP).	WP6	COP, DSS	FR-25, IR-1, IR-2, UR-12, UR-14	STWS
19	IWAT shall provide an intuitive UI.	WP6	All PLOTO modules	FR-26, UR-1, UR-2, UR-3, UR-4, UR-5, UR-6, UR-7, UR-8, UR-10, UR-11, UR-12, UR-14, UR-15, UR-16, IR-1, IR-2	STWS
20	IMS shall be able to manage incidents of specific types, e.g., flood, drought, and storm.	WP3, WP4, WP6	WP3, WP4 and WP6 modules	FR-18, IR-2	STWS
21	IWAT users shall be able to request maps of an area.	WP5, WP6	WP5 and WP6 modules	FR-21	STWS
22	IMS shall be able to present standard response procedures per incident type.	WP6	IMS	IR-4	STWS
23	PDDA should be able to connect to the necessary data (COP).	WP6	PDDA, Middleware	IR-8	UM

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
24	PDDA shall process data for purposes of monitoring water coverage/level changes.	WP6	PDDA	IR-8	UM
25	PDDA shall be able to provide an assessment of coverage/level based on historical data.	WP6	PDDA	IR-8	UM
26	PDDA shall provide information/alarms/events of water coverage/level changes.	WP6	PDDA	IR-8	UM
27	Communication among components/services integrated into the PLOTO platform should be performed through well-defined, open and/or widely accepted and secure APIs (e.g., REST APIs over HTTPS).	WP6, WP7	Middlewa re	NFR-1	INTRA
28	DevOps best practices must support software development activities to ensure the quick adaptation of any updates while detecting and preventing any issues efficiently.	WP6, WP7	WP6 modules, CI/CD	NFR-6	INTRA
29	Software containerization practices should be considered for the software components/services to minimize their dependency on the hosting/execution environments.	WP6, WP7	WP6 modules, CI/CD	NFR-7	INTRA
30	Satellite maps shall be available through the platform.	WP5, WP6	WP5 and WP6 modules	FR-21	STWS
31	Missions shall be created and forwarded to UAV.	WP5, WP6	WP5 and WP6 modules	FR-21	STWS

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
32	Data gathered by UAVs shall be available through the platform.	WP5, WP6	WP5 and WP6 modules	FR-21	STWS
33	All IWAT users shall be authorized and authenticated in order to use the platform.	WP6	Middleware, COP	FR-16	STWS
34	IWAT administrators shall be able to manage user accounts.	WP6	Middleware, COP	FR-19	STWS
35	All IWAT users shall have access to the role they are matched with.	WP6	Middleware, COP	FR-20	STWS
36	Middleware should integrate multiple services and sensors in a flexible and efficient way.	WP6	Middleware	IR-5, IR-7	RISA
37	Middleware should be able to accept, store, and provide information from sensors installed.	WP6	Middleware	NFR-3	RISA
38	Middleware should be able to collect and store several types of data and metadata.	WP6	Middleware	NFR-3	RISA
39	Middleware should be able to accept, store and retrieve input from COP/IWAT if this is deemed necessary.	WP6	Middleware	NFR-3	RISA
40	Middleware should store data and metadata and allow historical lookup and display through the COP/IWAT.	WP6	Middleware	FR-24, FR-25	RISA
41	Middleware shall restore the «lost» data upon communication recovery.	WP6	Middleware	NFR-3	RISA
42	Middleware should provide the data/output to all connected	WP3, WP6	Middleware	NFR-4, NFR-5	RISA

UID	System Requirement Description	Relative WP(s)	Relative module(s)	**Relative** end-user requirement(s)	Partner (s) responsible
	modules in a commonly accepted format.				
43	Middleware should develop algorithms that combine multimodal information to improve accuracy.	WP6	Middlewa re	FR-23, FR-24, FR-25	RISA
44	Middleware should fuse data and/or results to improve data accuracy and/or reduce the mean error of the values.	WP6	Middlewa re	FR-23, FR-24, FR-25	RISA
45	Middleware should provide the fused picture from the data to the COP/IWAT.	WP6	Middlewa re	FR-23, FR-24, FR-25	RISA
46	Middleware should provide a unique alarm based on sensor information received.	WP6	Middlewa re	FR-24, FR-25	RISA
47	Middleware should provide the COP/IWAT alarms/events coming from combined alerts/data/metadata for visualisation.	WP6	Middlewa re	FR-24, FR-25	RISA
48	Middleware should ensure secure communication, data transactions and data storage.	WP6	COP, Middlewa re	NFR-1	RISA
49	DT shall be able to represent in high resolution assets, as a stand-alone application.	WP6	DT	FR-27	STWS

5. System high-level architecture

The architectural design of the PLOTO system follows closely the Work Packages (WPs) structure of the project, which are the following:

- WP3: Atmospheric Forcing Modelling, Weather Now/ Fore-Casting and Data Processing
- WP4: Vulnerability and Resilience Assessment of the IWW and the connected hinterland infrastructures
- WP5: Earth Observation, Sensor Data and Geospatial Services for Increased Resilience of the IWW
- WP6: IWAT, Decision Support System and Enhanced Visualization Interface

Each WP is presented in the following paragraphs independently as a main element of the PLOTO system, including its internal architecture and data flow, highlighting communications between modules/components. Each module/component of the PLOTO System's elements (WPs) is responsible for creating detailed and specific datasets and models dedicated to the monitoring of specific hazards, risks or structures related to IWW. In creating such models, there is a need to collect data from external sources, intermediate model results, detailed model results (that are to be further used by other modules/components), as well as final models results (that are to be presented to the end-users). In the following paragraphs, the architectural design of the PLOTO system per element (WP) is presented.

Each elements are represented using the symbols present in Figure 2.

Figure 2: Architecture description symbols

More specifically, for each element (further to each main aim and description), the relevant modules are identified and for each module the following information is provided:

- **Module name:** The complete name of the module.
- **Module description:** A description about the aim and main characteristics of the module.
- **Module components:** List of components that the module consists of.
- **Sources:** List of the modules/components that provide data or any other input to the described module.
- **Input data:** Identification of the input data needed for the module to perform its regular operations.
- **Output data:** The expected outcome of each module.
- **Consumer:** Identification of the components/modules that feed from the activities or data produced by the described module.

5.1 WP3 high-level architecture

WP3 is responsible for the identification of extreme climate indicators and atmospheric stressors in connection to specific hazards. It also provides dynamic downscaling of the regional climate model predictions, simulation of average climate and extreme events in the meso-local-site scale, including an estimate of uncertainties. One activity of WP3 consists also to generate maps of quantified impact, extremes and environmental forcing at the local state. All input data in WP3 come from external sources: either provided by local partners when available or from on-line sources as needed. The outputs of WP3 are used by WP4 and WP6. Namely, WP4 uses the validated impact indicators and the downscaled climate models, and in WP6 the measurements and impact indicators are visualized and presented to the end-users.

The architectural diagram of WP3 is presented in Figure 3.

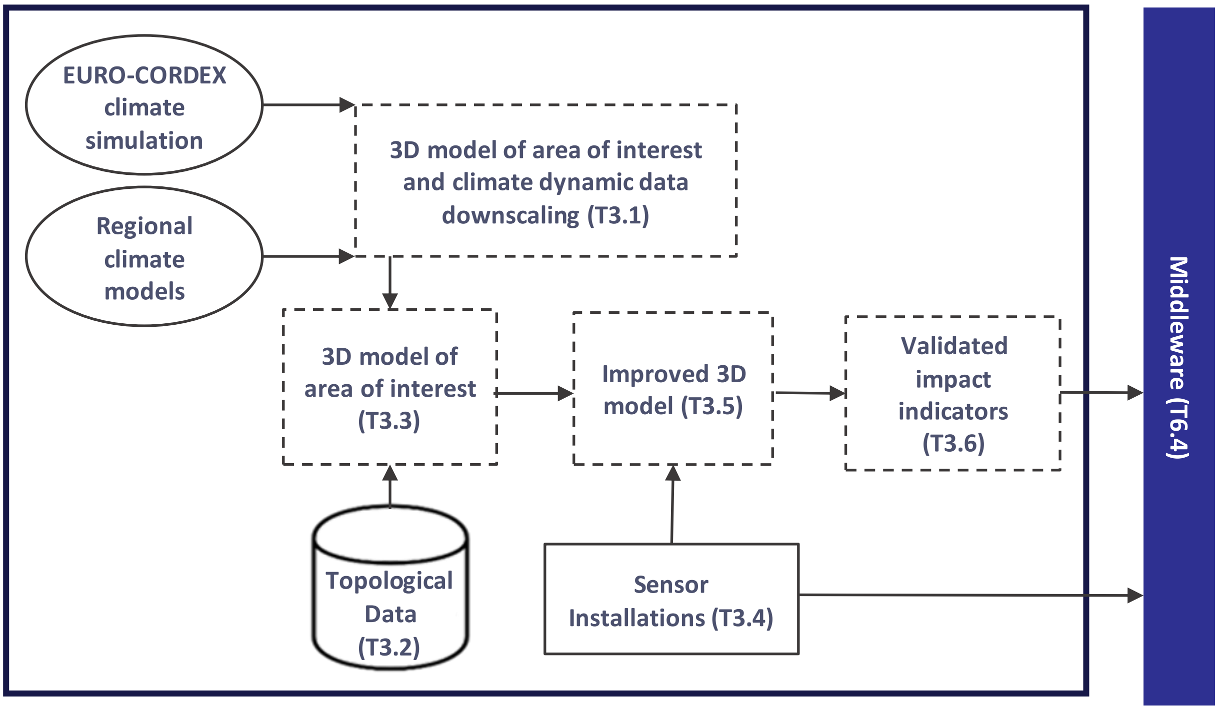

Figure 3: WP3 high-level architecture

5.2 WP4 high-level architecture

WP4 is responsible for the development of advanced models applicable on the IWW infrastructures for natural and man-made hazards, based on monitored data. Within this WP, a Multi-Hazard Vulnerability Assessment Module is being developed along with tools for modelling IWW assets. Bayesian model updating for near-real-time post-event site-specific vulnerability assessment will be provided.

WP4 utilizes the following inputs: impact indicators and downscaled climate models (from WP3); the routine and post-disaster monitoring of selected/important assets/ structures (from WP5); and the user validation of the model outputs after the realization of a hazard that will allow the overall assessment of the model performance and will inform of the need for the Bayesian update as needed (from WP6). The output of WP4 will be visualized and presented to the end-users through WP6 modules.

This WP consists of the following modules:

- Multi Hazard Model (WP3 and T4.1)
- Physical Vulnerability Assessment (T4.2)
- Business Continuity Model (T4.5)
- Risk Assessment Engine (T4.3)
- Physical Impact (T4.3)
- Socioeconomic Impact (T4.4)

The interconnection of the WP4 modules are schematised in an architectural diagram shown in Figure 4. Each modules are detailed in Subsections [5.2.1 - 5.2.6].

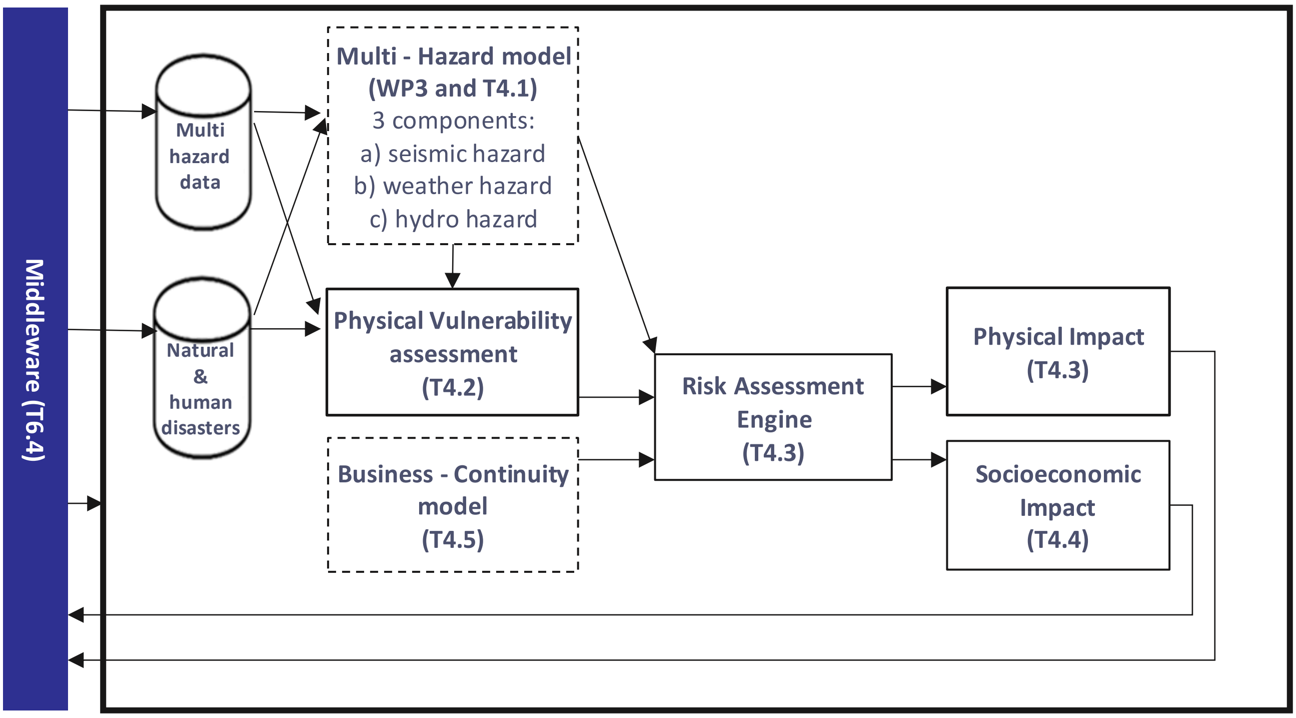

Figure 4: WP4 high-level architecture

5.2.1. Multi Hazard Model

The "Multi Hazard Model" module is related to WP3 and T4.1 and is responsible to: (a) assess all potential seismic hazard scenarios and related ground motion fields per pilot; (b) provide CFD simulation data, mesoscale model fore/now-casting, EuroCORDEX scenario data downscaled information per pilot; and (c) provide water elevation & return periods for all potential flood & drought scenarios. Three types of hazard are considered: seismic hazard, weather hazard and hydro hazard.

In Table 7, a summary of the sources/input data, as well as the consumers/output data of the module are displayed. For further details on the data used (type, file format, size etc.), please check Appendix 1.

Table 7: "Multi Hazard Model" module

Input Data	**Output Data**
• Seismic source model • Sensors, mesoscale model, CFD datasets, weather station data, EuroCORDEX • Water elevation sensors, regional forecasts, hydrological model, precipitation sensors	• Scenario events, ground motion fields • Scenario events, weather intensity measure fields, forecasts and nowcasts • Scenario events, water level maps, forecasts and nowcasts
Sources	**Consumer**
• External earthquake alert service • Weather sensors • Hydro sensors	• Physical Vulnerability Assessment (T4.2) • Risk Assessment Engine (T4.3)

5.2.2. Physical Vulnerability Assessment

The "Physical Vulnerability Assessment" module assesses fragility and vulnerability curves for all assets of interest. In Table 8, the sources/input data, as well as the consumers/output data of the module are displayed. For further details on the data used (type, file format, size etc.), please check Appendix 1.

Table 8: "Physical Vulnerability Assessment" module

Input Data	**Output Data**
• Asset exposure database, detailed structural drawings for selected/important assets/ structures, structural models	• Fragility and vulnerability curves
Sources	**Consumers**
• No input from other modules. • Data and details of structures are the input to create surrogate or detailed structural models that are analyzed to produce the fragility curves.	• Risk Assessment Engine (T4.3) • Business Continuity Assessment (T6.2)

5.2.3. Business Continuity Model

The "Business Continuity Model" module provides a business and organisational model for the pilot facility as well as a regional socioeconomic model for the surrounding areas. In Table 9, the sources/input data, as well as the consumers/output data of the module are displayed. For further details on the data used (type, file format, size etc.), please check Appendix 1.

Table 9: "Business Continuity Model" module

Input Data	Output Data
• Facility organization plan, personnel data, available business continuity plan, Business Interruption Tables, Input-Output Regional economy tables.	• Business performance per facility component/sector, economic performance per regional sector
Sources	**Consumer**
• No input from other modules. • Input data from external sources, such as mode of transportation for the supply of the city, e.g., rail, road trucks, etc., number of residents (population), number of visitors per month, Gross Value Added (GVA) for the main business sectors.	• Risk Assessment Engine (T4.3) • Business Continuity Assessment (T6.2)

5.2.4. Risk Assessment Engine

The "Risk Assessment Engine" module combines hazard and vulnerability data to assess the risk from all pertinent hazards. In Table 10, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1 for further details).

Table 10: "Risk Assessment Engine" module

Input Data	Output Data
• All hazard data, all vulnerability data, all business continuity data	• Risk metrics per hazard scenario
Sources	**Consumer**
• Seismic/Weather/Hydro hazard, Physical Vulnerability Model, Business Continuity Model. • Multi hazard model (T4.1) • Physical vulnerability assessment (T4.2) • Business continuity model (T4.5)	• Physical Impact module (T4.3) • Socioeconomic Impact module (T4.4)

5.2.5. Physical Impact

The "Physical Impact" module assesses the consequences of hazard events on the physical condition of all assets of interest. The sources/input data, as well as the consumers/output data of the module are displayed in Table 11 (please check Appendix 1 for further details).

Table 11: "Physical Impact" module

Input Data	Output Data
• Risk metrics per hazard scenario • Asset exposure	• Damage state, loss magnitude and downtime timeseries per asset
Sources	**Consumer**
• Risk Assessment Engine (T4.3)	• Decision support system • IWAT

5.2.6. Socioeconomic Impact

The "Socioeconomic Impact" module assesses the consequences of hazard events on the business and organizational aspects of the facility as well as the social and economic function of the surrounding areas. In Table 12, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1 for further details).

Table 12: "Socioeconomic Impact" module

Input Data	Output Data
• Risk metrics per hazard scenario, business continuity data	• Loss per organization parts, facility downtime and functionality time series, loss per socioeconomic sector, sector downtime and functionality timeseries
Sources	**Consumer**
• Risk Assessment Engine (T4.3)	• Decision support system • IWAT

5.3 WP5 high-level architecture

WP5 employs Unmanned Aircraft Systems (UAS), aiming to provide a comprehensive IWW monitoring system both for routine inspection and damage assessment after disasters and accidents via drones and satellites. The system will integrate data from various remote sensing platforms such as satellites, UAV and ground-based monitoring systems in order to cover the specific monitoring needs for the demonstration areas and selected/important assets/ structures.

All input data fed into WP5 come from external sources: primarily local partners, or on-line sources, if necessary. Multiple outputs of the WP5 are used as inputs in other packages: the routine and the post-disaster monitoring of the Tier 1 buildings (input for WP4); and all collected routine and post-disaster building monitoring data (input for WP6).

This WP consists of the following modules:

- Enhanced drone and satellite ground control station (T5.2)

- Multi-sensor Flaw and Degradation Assessment (FDA) system (T5.3)
- Post Disaster Damage Assessment (PDDA) (T5.4)

The WP5 modules are interconnected following the architectural diagram displayed in Figure 5. The modules are detailed in Subsections [5.3.1 - 5.3.3].

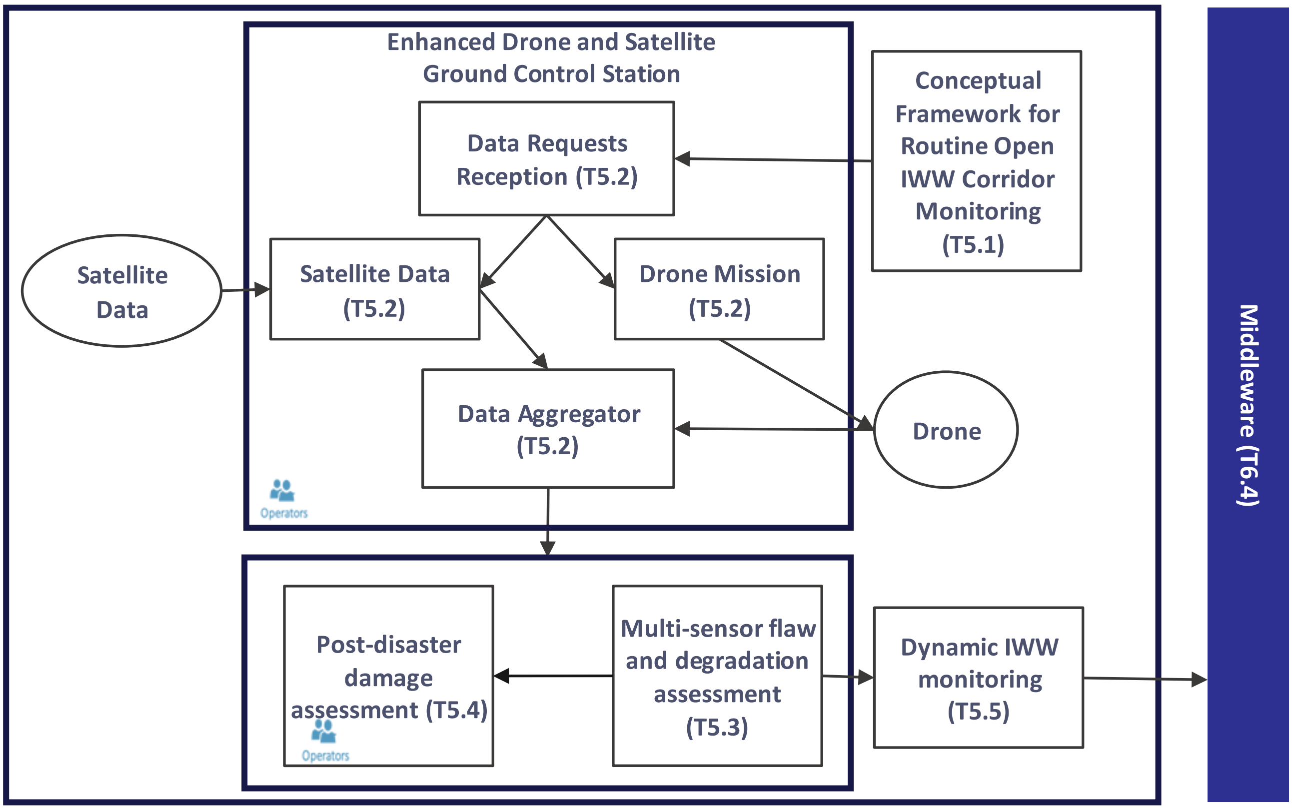

Figure 5: WP5 high-level architecture

5.3.1. Enhanced Drone and Satellite Ground Control Station

This module is related to satellite and drone monitoring ground stations that enable routine inspection and damage assessment after disasters and accidents via drones and satellites. It consists of the following components: data requests reception, drone mission, satellite data, data aggregator, and front-end application. In Table 13, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1 for further details).

Table 13: "Enhanced Drone and Satellite Ground Control Station" module

Input Data	Output Data
• Input from Conceptual Framework for Routine Open IWW Corridor Monitoring (T5.1) • Input from IWAT platform (T6.1) • Input from IMS (T6.7)	• Satellite and drone monitoring capability. • Interfacing with applications developed in T5.3 & T5.4, through the middleware layer.
Sources	**Consumer**
• Conceptual Framework for Routine Open IWW Corridor Monitoring (T5.1) • IWAT platform (T6.1) • IMS (T6.7)	• Post-disaster damage assessment (T5.4) • Multi-sensor flaw and degradation assessment (T5.3)

5.3.2. Multi-sensor Flaw and Degradation Assessment System - FDA (mFDA & sFDA)

The multi-sensor Flaw and Degradation Assessment system (FDA) consists of two separate components according to the input data, the Multi-sensor Flaw and Degradation Assessment (mFDA) and the Satellite Flaw and Degradation Assessment (sFDA).

The mFDA uses RGB/ Thermal/ Hyperspectral/ Point cloud data to detect types of alternations on important infrastructures / assets in 2D - 3D space using multi modal data. The mFDA component is implemented and exploits photogrammetric and machine learning algorithms. Additionally, mFDA integrates information from multi modal data in a 4D perspective.

The sFDA uses satellite data to develop a tool that will combine methodologies to build an operational monitoring system. Products such as IWW, Land-Cover and Land Use and Deformation maps etc., will be generated. The sFDA includes the optimized versions of methods developed in WP5, under the umbrella of an effective and operational monitoring system.

In Table 14, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1for further details).

Table 14: "Multi-sensor flaw and degradation assessment" module

Input Data	Output Data
• RGB / multichannel / Thermal images, Point clouds (LiDAR, Laser Scanner) etc. In general 3D information is needed. • Data acquired/produced from T2.4 and WP5.	• Maps and reports of structural deformations and other types of alterations. The optimized methodology of routine detection, characterization and quantification of the degradation issues to the IWW as well as the damage types.
Sources	**Consumer**
• PLOTO geographic data (T2.4) • Conceptual Framework for Routine Open IWW Corridor Monitoring (T5.1) • Data Aggregator (T5.2) • Post-disaster damage assessment (T5.4)	• Dynamic IWW monitoring (T5.5)

5.3.3. Post Disaster Damage Assessment (PDDA)

PDDA provides services for situation assessment by fusion of datasets (satellite, LiDAR, etc.) in order to allow the detection of alterations e.g. in water levels. It consists of the following components: front-end application, data access connectors, map creation tools, geospatial object attributing tools.

In Table 15, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1 for further details).

Table 15: "Post Disaster Damage Assessment" module

Input Data	Output Data
• Inputs from WP2, WP3 and WP4	• Water level profiles
Sources	**Consumer**
• Data Aggregator (T5.2)	• IWW and other land-infrastructure operators

5.4 WP6 high-level architecture

WP6 is dedicated to bringing together all the information developed in the previous WPs (elements) (through the middleware) to the end-users by using multiple interfaces. In doing this, multiple developments will be created:

- the IWAT modelling and simulation environment for assessing the resilience of IWW and assesses potential impacts due to various hazards (drought, flood, extreme weather, etc.) and for supporting the identification of vulnerable elements and of cost-efficient adaptation measures;

- the development of AI and data fusion algorithms;
- the COP generation for all relevant authorities and operators;
- the IMS adaptation and DSS development;
- the development of the IWW Digital Twin.

Moreover, within T6.2, the business continuity models and adaptation strategies for demonstration cases (end-users) will be evaluated and updated in order to better cope with CC and improve their mitigation strategies.

This WP consists of the following modules:

- eXplainable Artificial Intelligence for GeoInterpretation (GeoXAI) (T6.5)
- Business Continuity Assessment (T6.2)
- DigitalTwin (DT) (T6.8)
- Common Operational Picture – COP (T6.6)
- Standard Response Procedures (T6.3)
- IWW Assessment Platform – IWAT (T6.1)
- Incident Management System & Decision Support System - IMS/DSS (T6.7)
- Middleware and Data Fusion (T6.4)

WP6 modules and components interact together according to the respective architectural diagram depicted in Figure 6.

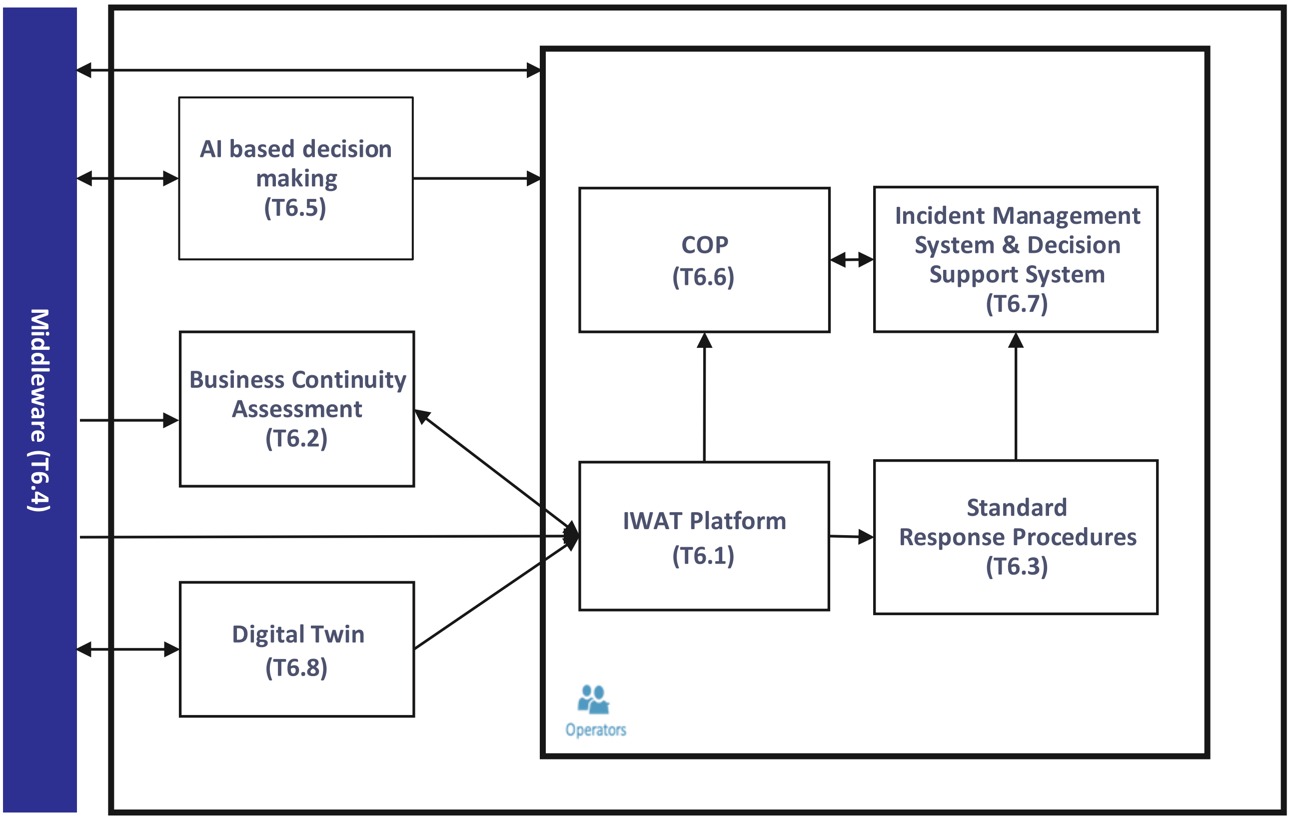

Figure 6: WP6 high-level architecture

5.4.1. eXplainable Artificial Intelligence for GeoInterpretation (GeoXAI)

The GeoXAI will apply a set of eXaplainable AI algorithms to efficiently interpret Artificial Intelligence models developed under the projects WP4, WP5 and WP6. The outcomes of the proposed framework will be feature importance graphs, dependence plots, correlation maps, force plot explanations, beeswarm explanation plots and feature attribution maps over images.

The GeoXAI includes the following algorithms:

- SHAP is a game theoretic approach for interpreting machine and deep learning models. It provides the end-user explanations by computing each feature's contribution towards the prediction, which can be either positive or negative.
- LIME explains the predictions of a deep or machine learning classifier or regressor (model-agnostic), by approximating the initial model locally with surrogate-interpretable models, assuming that in local scale the model is linear.

In Table 16, the sources/input data, as well as the consumers/output data of the module are displayed. Please check Appendix 1 for further details.

Table 16: "eXplainable Artificial Intelligence for GeoInterpretation" module

Input Data	Output Data
• Data acquired / produced from WP4, WP5	• SHAP Image plot, SHAP Feature Importance Plot, SHAP Summary Plot, SHAP Decision plot, SHAP dependence plot, SHAP Force Plots, Heatmaps for Band-wise feature Importance, LIME Image and Tabular Explanations
Sources	**Consumer**
• WP4 • WP5	• AI-related developers for the IMS/DSS (T6.7) • IWW projects components

5.4.2. DigitalTwin (DT)

The DT will predict location and time of future flooding, or drought and related risks for the three use cases. In Table 17, the sources/input data, as well as the consumers/output data of the module are displayed. Please check Appendix 1 for further details.

Table 17: "Digital Twin" module

Input Data	Output Data
• Water level data • Weather data • Sensor data	• What-if scenarios that show the location of flooding/drought events in the 3 use cases.
Sources	**Consumer**
• Hydraulic and Hydrological models	• IWAT (T6.1)

5.4.3. IWW Assessment Platform – IWAT

IWAT is a modelling and simulation environment for assessing the resilience of IWW and potential impacts assessment due to various hazards (e.g., drought, flood, extreme weather). IWAT includes authoring tools to design the IWW interdependences logic in terms of functional flow blog diagrams. In this, clearly defined plug-in mechanism, new algorithms/analyses can be added anywhere along the analysis workflow enabling scientists to create new end-to-end analyses, enhance existing analyses, model various hazards impacts on IWWs, develop risk reduction strategies and implement adaptation strategies to minimize their impact on societies.

In Table 18, the sources/input data, as well as the consumers/output data of the module are displayed (please check Appendix 1 for further details).

Table 18: "IWW Assessment" module

Input Data	Output Data
• Impact assessment models (T4.5) • Modelling tools WP3 • Scenarios/workflows	• Impact & risk assessment results
Sources	**Consumer**
• All WP4 components	• DSS (T6.7) • COP (T6.6)

5.4.4. Common Operational Picture – COP

PLOTO information, such as climate data and services, fused and raw data from sensors (ground, space and UAVs), simulation results, vulnerability information as well as all IWW elements and metadata in terms of GIS information layers will be presented on the COP.

The COP will provide assistance to IWW and other land-infrastructure operators during maintenance as well as all phases of a crisis incident by providing all the available information regarding the current situation on a unified graphical user interface. IWAT will also be used as a rapid assessment system.

In Table 19, the sources/input data, as well as the consumers/output data of the module are displayed.

Table 19: "Common Operational Picture" module

Input Data	Output Data
• Data provided by middleware (data fusion layer) and the digital twin	• Common Operational Picture of the situation
Sources	**Consumer**
• Middleware (T6.4) • Digital Twin (T6.8)	• IMS (T6.7) • DSS (T6.7) • IWW and other land-infrastructure operators

5.4.5. Incident Management System (IMS) & Decision Support System (DSS)

The IMS will be used by IWW operators to manage the day-to-day incidents and maintenance processes. It will also host the same User Interface (UI), the COP, and the IWAT components. The module includes two functionalities, IMS and DSS :

- The IMS is the component that helps operators manage daily routine incidents or maintenance tasks. This system will implement protocols for multiagency interaction and communication to integrate and synchronize actions of participating organizations and jurisdictions to ensure unity of effort. It will also permit the collaborative response of all involved relevant local and regional partners to efficiently implement response strategies in order to stabilize the incident and accelerate the transition to recovery.

- The DSS is the standard response procedures defined for every hazard will be integrated as a workflow of proposed actions or lists of proposed resources to be deployed.

In Table 20, the sources/input data, as well as the consumers/output data of the module are displayed. Please check Appendix 1 for further details.

Table 20: "Incident Management & Decision Support" module

Input Data	Output Data
• Standard Response Procedures • Common Operational Picture • Risk based planning capabilities • Mitigation solutions	• Incident Management • Decision Support Capabilities
Sources	**Consumer**
• Standard Response Procedures (T6.3) • COP (T6.6)	• IWW operators

5.4.6. Middleware and Data Fusion

The middleware collects, processes and provides data and information to other modules and applications in a meaningful way. It incorporates current information systems (IWW, climate and weather forecast models, etc.), but also data available from sensor networks (satellite, GPS, cameras, weather-climate stations, etc.). It coordinates information delivery between control and device planes, accompanied by effective, scalable service assurance.

PLOTO middleware will consist of 6 components:

- Abstraction layer in which the information from different sources will be available in the same format. This layer will provide uniform and transparent access to IWW data systems, services and sensor networks.
- Resources management framework/fusion provides components for storing, retrieving and managing metadata and data, as well as for filtering, aggregating, and fusing of data.
- Complex Event Processing (CEP) coupled with Data Fusion (DF) will be performed. Event management, filtering and contextual information modules will handle all the events from the data sources and will categorise retrieved events and information into proper categories for better understanding and processing from the PLOTO platform.
- Ontologies and semantic representation layer will create a base layer of common/standardised knowledge of the different IWW related resources/information with the proper metrics to be organised and create the connection between that info. Semantic interoperability will be created.

- Communication management module in which all the appropriate interfaces/protocols for communication with the different data sources exist.
- Security and privacy module that tackles data and identity security and privacy aspects.
- Data Fusion module will sort, filter and process data from all high-level architecture, present in the middleware in a convenient way to communicate to DSS and relevant authorities.

PLOTO's Data Fusion module will consist of three layers:

- **Layer 1:** In this Layer, all the preprocessing of the different PLOTO data sources from sensors and information systems will be adapted to a uniform format for further processing for Layer 2. Layer 1 will also be responsible for data virtualization, meaning that virtual entities (objects) with logically similar attributes will be created from the data coming, without representing a specific data source. Raw data will be forwarded to resources framework and Layer 1 activities will be performed in the abstraction framework part of the PLOTO middleware.
- **Layer 2:** In this Layer, the main DF and data processing will be performed by the PLOTO Resources Management/ Fusion framework. The main data processing will be done here focusing on data integration from various sources retrieved after the data preprocessing stage. Four modules will undertake this extensive procedure: a) The Event Manager (EM), b) the DF Manager c) the CEP Engine and d) Reasoning Engine. The data will be delivered as a payload of events pushed by the EM that will work as an event broker. Such data will be collected and fused by the DF Manager, applying the stored DF-queries. As the fusion happens, new events can be generated from the query results, and can participate in further fusions to generate complex or aggregate data streams. This Layer will provide fused information through the Middleware API ready to be used for all DSS tools and for every specific application and module (Climate models, Geospatial Framework, Weather Forecast). Finally, raw data will be available to all high-level modules and applications for further application driven processing.
- **Layer 3:** In this layer, DF related to specific application processing will be executed if needed in order to make available the data in meaningful way to operators and relevant authorities. The DSS will retrieve data from Layer 2 and will support decisions to the operators.

In Table 21, the sources/input data, as well as the consumers/output data of the module are displayed. For further details on the data used (type, file format, size etc.), please check Appendix 1.

Table 21: "Middleware and Data Fusion" module

Input Data	**Output Data**
• Input from WPs 3, 4 and 5	• Output to WPs 4 and 6
Sources	**Consumer**
• Input from WPs 3, 4 and 5	• Output to WPs 4 and 6

5.4.7. Assessing Business Continuity Models and Adaptation Strategies

Following the development of the organisational resilience and impact assessment model on the IWW (T4.5), in T6.2, a large set of different scenarios will be developed to allow IWW to better cope with climate change and also develop mitigation strategies in order to ensure the minimum continuous operation in case of an event. The outcome will be provided in IWAT (Table 22).

Table 22: Assessing business continuity models and adaptation strategies outline

Input Data	**Output Data**
• Characteristics of various hazards • Operating principles and best practices • Critical components of IWW	• Large set of different scenarios for IWW • Cope with Climate Change • Mitigation strategies
Sources	**Consumer**
• Business continuity model (T6.2)	• IWAT platform (T6.1)

5.5 General high level architecture

The analysed high-level architectures of WP3, WP4, WP5 and WP6 (as presented respectively in Figure 3, Figure 4, Figure 5, Figure 6) can be consolidated in a single architecture that is displayed in Figure 7. To facilitate its access, a platform is under development (as explained in Section 5.6). At this point it should be mentioned that the architecture might get updated /extended, as the project evolves.

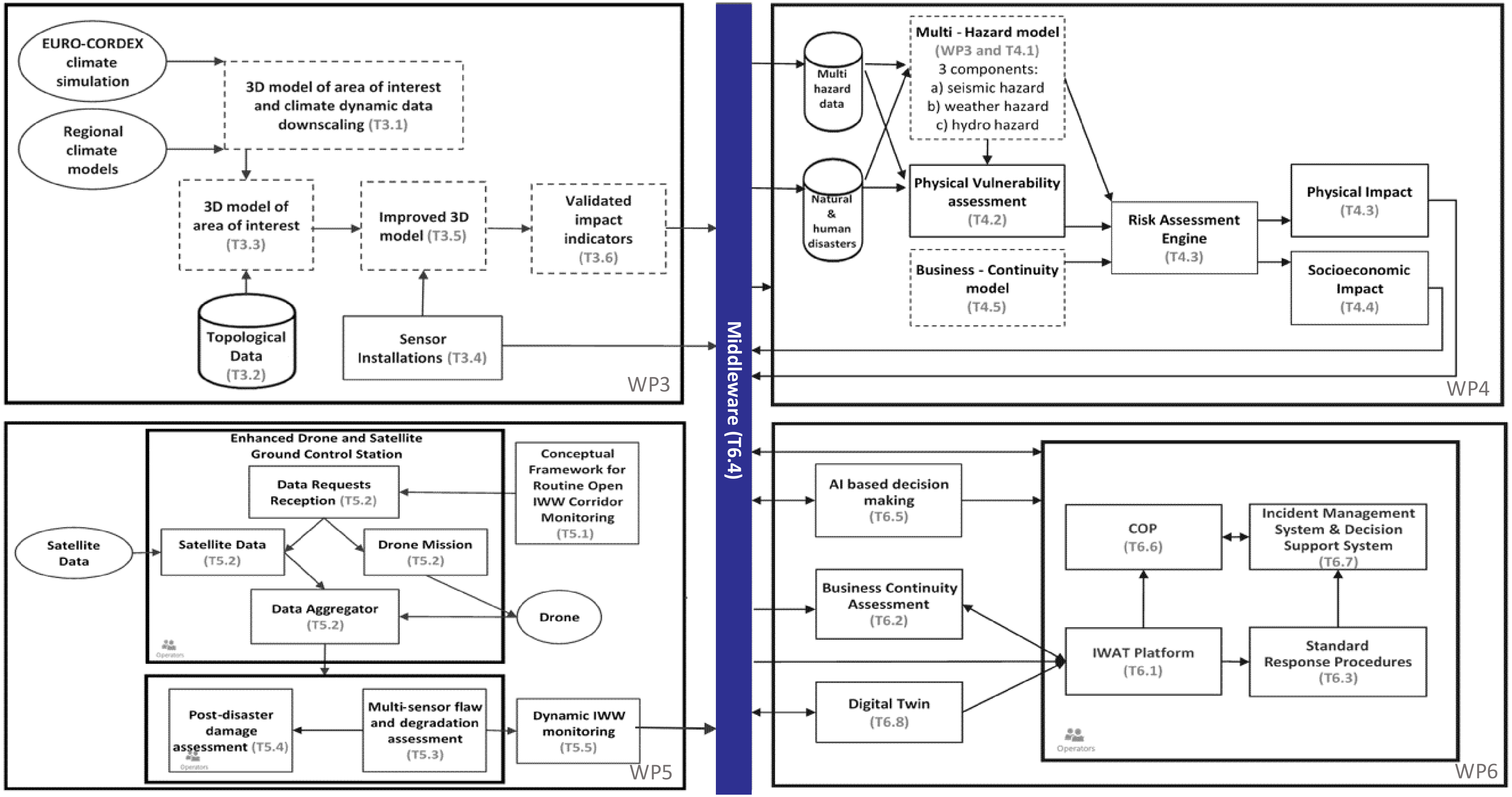

Figure 7: PLOTO high-level architecture

5.6 Platform development and testing environment

To guide the PLOTO platform development, a suitable development environment will be set-up, allowing ongoing automation and continuous monitoring of the development, testing and integration processes. In essence, the PLOTO platform development/testing environment will set the ground for the instantiation of PLOTO architecture system components and their gradual integration into a unified (end-to-end) system. This will be done through a well-defined software integration framework and a repetitive process ensuring that proper feedback will be provided to the developers for any blocking issues and required bug-fixing/improvements for their components. The integrated PLOTO platform will primarily focus on the incorporation and interoperability of WP6 components consisting the main system-wise, PLOTO software components to be delivered to the end-users. As described in section 5.4, WP6 components bring together the information/data collected from components/modules of WP3-5. To this end, the interfaces and data exchanges of WP6 components with relevant WP3-5 components/modules should also be defined and tested.

DevOps best practices will be put in place to optimize the software development and delivery lifecycle. A Continuous Integration and Continuous Delivery/Deployment (CI/CD in short) methodology will be followed and implemented through a set of associated software tools. The objective will be to provide the individual components to the developers with an appropriate environment and tools to build, test and deploy their code developments and updates, in an automated manner that will facilitate proper integration and validation of the components before their deployment in an operational context (i.e., pilot execution environments). CI principles are aligned with frequent software integration attempts (shortening the software development cycles), and therefore allow for early detection of any arising issues and long backtracking procedures.

A key element of the DevOps best practices that will be followed for the PLOTO platform is the containerization of the developed software components. Containerization is a well-known virtualization and software packaging approach in which all the subcomponents and software dependencies of an application can be bundled together in a single container image and then instantiated in an isolated user space of a shared operating system. To this end, it provides many benefits from a deployment, performance and security perspective:

- Software isolation allows applications/services to run as isolated units within containers totally separated from other applications running at the same operating system. This is a good security practice in the sense that different applications/services running at the same host cannot interfere with each other.
- Software portability allows developers to move and deploy their applications easily among different hosting environments (cloud, OS) with minimal requirements (e.g., application container requiring to be hosted in a Linux OS). For the case of the PLOTO, this is convenient, considering that once the PLOTO components get tested at the development/testing environment, they can easily be replicated in the demonstration environment.
- Containers are generally lightweight and easily scalable. In this context, their build and execution (startup) times can be minimized, which is aligned with the need for CI/CD pipelines to be executed quickly, to decrease the software development cycles. Similarly, containers

can easily scale, making it straightforward to create multiple replicas of an application to comply for increasing service demands, redundancy, fault-tolerance requirements etc.

- The development/testing environment and the corresponding CI/CD system will be provided from INTRA in the context of WP7/T7.1 and will be hosted in Hetzner public cloud provider (Hetzner, 2023), within dedicated servers (virtual machines) that will be acquired for PLOTO. The main components/tools of the CI/CD system that will be implemented from INTRA and used from PLOTO software component providers are the following: Code hosting repository with version control, access control and issues tracking.
- CI server to implement and manage automated build, testing and deployment pipelines, automatically triggered from software updates.
- Private repository (registry) to host and distribute the produced software artifacts (e.g., software container images generated from build pipelines through the CI server).
- Development servers to host the deployed instances of software artifacts (e.g., software containers) and their interconnections. Proper testing will be defined and run on top of such instances to verify the intended functionality and interoperability among the components at different levels (functional, integration, end-to-end).
- Logging, notification and health monitoring utilities that will be put in place at the different stages of the CI/CD workflows.

The relation and dependencies among the aforementioned CI/CD components are depicted in Figure 8. It is envisioned that the feedback for the different stages of the build, testing and deployment pipelines will be communicated to the users/developers of the CI/CD system through the CI server.

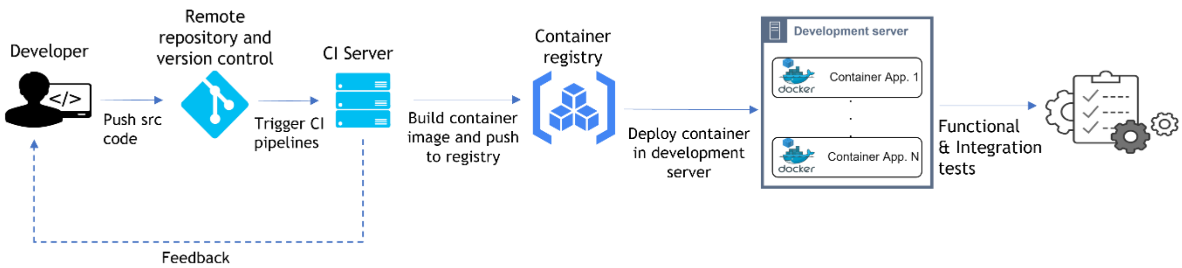

Figure 8: CI/CD development and testing workflow

6. Use cases and scenarios

PLOTO will perform extensive tests in three different demo sites, as presented below:

- The first demonstration will be executed in Danube area, which includes inland waterways and ports. The partners involved in this Use Case are the following: (a) **AFDJ** - **Lower Danube River Administration**, as the national inland waterway administration may provide full set of qualified, official data on the sector consisting of the Sulina Bar, the Sulina Canal, and the Maritime Danube up to the ports of Braila and Galati concerning: water levels, water speed and direction, water discharge, water temperature, wind speed and direction, bathymetric data, as well as sediments; (b) **UDG – Danubius University of Galati,** Department: Danubius Institute for Business Strategies – socioeconomic studies, co-definition of research and market needs, business consultancy, IPR management, training and research dissemination; and (c) **RRT - Romanian River Transport Cluster -** inventory and mapping the situation in Galati, Braila and Tulcea ports, dissemination and facilitation of the discussion on the adaptation and mitigation measures in ports and the innovative business solutions and exploitation of project results.
- The second demonstration will be conducted in Budapest port, which is connected to the railway network. The partners involved in this Use Case are the following: (a) **BSZL - Freeport of Budapest Logistics Ltd.:** coordination and operation of trimodal (waterway, railway, road) logistics services, data provision; (b) **MÁV – Hungarian State Railway Company:** providing accessibility to railway network and related services, data provision; (c) **RSOE – National Association of Radio Distress-Signalling and Infocommunications:** connection to shipping and port information system, data provision and analysis and (d) **BME – Budapest University of Technology and Economics, Department of Transportation Technology and Economics:** situation analysis, consultancy activity, survey of user requirements, discussion on the adaptation and mitigation measures, training, socio-economic studies, and innovative business solutions, demonstration and validation activities, dissemination, and exploitation of project results.
- The third demonstration will take place in the Walloon region in Belgium. It focuses on a section of an IWW (between Liège and the Belgian-Dutch border and on the assets in the hinterland potentially at risk in case of dike breaching along the IWW. The partners involved in this Use Case are the following: (a) **Service Public of Wallonie (SPW MI):** Provision of field data and access to facilities for testing solutions; and (b) **University of Liège (ULiege):** Processing and analysis of data, hydrodynamic modelling, impact analysis.

The demonstrations shall prove the suitability of the PLOTO platform for multiple hazard assessment, and the optimized operational & strategic decisions for management and maintenance, either considering hazards relevant for other sections of the same corridor, or for other critical parts of the IWWs. The demonstrations will focus on the following main objectives:

- to improve multiple-hazard assessment and strategic management for protection of hotspots of the IWW ports and sections;
- to improve strategic and operational decision making;

- to test the various PLOTO outcomes and the overall integrated DSS tool with actuation technologies in real scale critical parts of the IWW.

In the following paragraphs, and further to the information collected and presented in D2.1, the relevant Use Cases scenarios will be provided. The PLOTO scenarios are classified into three main categories based on their time relation with the examined event, the knowledge available during the event and the time frame for any actions. In detail, the scenarios are characterized based on their time relation with the examined event, such as:

- **Pre-event**, the system is tested on IWW scenarios that are probable to happen aiming to identify vulnerabilities and mitigation actions that will improve the resilience of the examined area.
- **Trans-event (Near real time)**, the system is tested on a scenario that has just happened, or is still in progress, aiming to identify possible issues/damages and improve the response time of the authorities to the event.
- **Post-event**, actions that can take place after the end of an event, as a warning for a potential issue or as a confirmation/notification about an issue.

The scenarios are also characterized based on the knowledge that is available at the time:

- **Given damage**, the system is triggered based on damage (either real/observed or probable/predicted) to an asset of the area of interest.
- **Given hazard**, the system is triggered based on a hazard (either real/observed or probable/predicted) that has materialized or can materialize at the area of interest.
- **No given**, the system is triggered without any additional input of knowledge on the current status of the assets and/or hazards beyond what is already in place and it is expected to assess "all" potential scenarios of given damage or given hazard and combine them to provide a hierarchy of consequences based on the probabilities of them materializing.

The scenarios are also identified based on the time frame for the implementation of the mitigation actions:

- **Long term planning**, the mitigation actions provided by the system will be used to support the improvement of the resilience of the IWW based on budget availability and needs.
- **Short term planning**, the mitigation actions provided by the system will be implemented as soon as possible to limit the immediate consequences of a hazard.

According to the aforementioned classification, PLOTO will examine, implement and test a set of scenarios, which will fully demonstrate the potential of the project outcomes. The scenarios are outlined in Table 23, where red cells correspond to short- term planning and green cells refer to long-term planning, and described in detail in the following paragraphs.

Table 23: Summary of PLOTO Use Case scenarios

	No Given	Given Hazard	Given Damage
Pre-event	Scenario 1	Scenario 2	Scenario 3
Trans- event			Scenario 4
Post-event	Scenario 5		

6.1 Pre-event Scenario

6.1.1. Scenario 1: No givens, long-term planning

Scenario Description

Once per year, the AFDJ - Lower Danube River Administration decides on how to distribute the budget on the different IWW assets (buildings, channels, maintenance etc.).

The user, accesses the IWAT/COP and selects the assets that he/she is interested in. Based on this selection, a hierarchy of risk prioritization as well as the expected consequences are presented.

Due to Climate Change, the climate model predicts a significant increase in winds in a specific area for the upcoming decade. The structural model also knows that in this area two of the buildings that constitute the port facilities are suffering from some yet-unrepaired damage due to an earthquake that took place earlier this year. The user is made aware that these buildings are in danger of collapse. The user prioritizes the restoration works for these buildings, adding to the AFDJ budget the needed money.

Afterwards, the user is accessing the DSS, where some long-term mitigation actions that will improve the resilience of the IWW are presented.

Knowing that the port is in an active seismic zone, the user is not surprised that there are areas affected by recent seismic activities that require some additional support to ensure that no structural problems will arise to the port facilities. Hence, the User receives consulting on the financial risks involved in the event of the destruction of these facilities and the user makes the needed adjustments to the investment plan.

Rationale

The rationale behind this scenario is to showcase the usability of the IWAT/COP platform, and the demonstration of certain system modules that meet PLOTO’s Scientific and Technical Objectives (STOs), shown in Table 24.

Table 24: Rationale behind Scenario 1

PLOTO Module	Relevant STOs
IWAT platform (T6.1)	STO-1, STO-6
Common Operational Picture (T6.6)	STO-1, STO-6
Multi - Hazard Model (WP3 and T4.1)	STO-1, STO-2, STO-4, STO-8
Physical Vulnerability Assessment (T4.2)	STO-1, STO-8, STO-5
Risk Assessment Engine (T4.3)	STO-1, STO-5
Physical Impact (T4.3)	STO-1, STO-5
Socioeconomic Impact (T4.4)	STO-1, STO-5
Business Continuity Assessment (T6.2)	STO-1, STO-5
IMS & DSS (T6.7)	STO-1, STO-6
Middleware and Data Fusion (T6.4)	STO-1, STO-8

6.1.2. Scenario 2: Given hazard intensity, short-term planning

Scenario Description

Civil Protection has raised the alarm about extreme weather phenomena in an area. The user is informed that the upstream river area will suffer from extreme rainfalls where the precipitation, in a small-time range, is expected to be twice the amount of water usually reaching the area within the month.

The user knows that this is a phenomenon never again encountered and the user is worried about the possible issues that may occur. The user is accessing IWAT/COP, selects the port interested in and initiates the targeted scenario. Through an easy-to-use interface, the user is adding the information that is available, namely expected rainfall and wind intensities as well as the time frame of the phenomena.

The user receives a list with the possible risks prioritized, the expected consequences as well as immediate mitigation actions. The user is now aware of the areas that will be the most affected by the upcoming phenomenon as well as the measures that should be taken to minimize the consequences.

Rationale

The rationale behind this scenario is to showcase the usability of the IWAT/COP platform, and the demonstration of certain system modules that meet PLOTO's technical objectives, shown in Table 25.

Table 25: Rationale behind Scenario 2

PLOTO Module	Relevant STOs
IWAT platform (T6.1)	STO-1, STO-6
Common Operational Picture (T6.6)	STO-1, STO-6
Midlleware and Data Fusion (T6.4)	STO-1, STO-8
Multi - Hazard Model (WP3 and T4.1)	STO-1, STO-2, STO-4, STO-8
Physical Vulnerability Assessment (T4.2)	STO-1, STO-8, STO-5
Risk Assessment Engine (T4.3)	STO-1, STO-5
Physical Impact (T4.3)	STO-1, STO-5
Socioeconomic Impact (T4.4)	STO-1, STO-5
Business Continuity Assessment (T6.2)	STO-1, STO-5
Digital Twin (T6.8)	STO-5, STO-8

6.1.3. Scenario 3: Given damage, long term planning

Scenario Description

A recent social media post has published some photos of hairline cracks in a dyke. While the authorized User is not worried, and has ensured that the damage is superficial, the user is wondering what the consequences will be for the local economy in such a case.

The user accesses IWAT/COP and manually assigns damages to selected dykes. The platform allows to identify the flood zone and classify community assets as totally destroyed or partially affected. After this characterization, the user can see an estimation of the consequences to the local economy as well as a list of mitigation actions.

The user communicates with the local government to ask about the preparedness measures in place as well as running training scenarios and going through table top exercises to test mitigation actions or rehabilitation options.

Based on these communications, the user is taking the needed decisions to update the infrastructure and ensure the sustainability of his operations in the long term.

Rationale

The rationale behind this scenario is to showcase the usability of the IWAT/COP platform, and the demonstration of certain system modules that meet PLOTO's technical objectives, shown in Table 26.

Table 26: Rationale behind Scenario 3

PLOTO Module	Relevant STOs
IWAT platform (T6.1)	STO-1, STO-6
Common Operational Picture (T6.6)	STO-1, STO-6
Middleware and Data Fusion (T6.4)	STO-1, STO-8
Risk Assessment Engine (T4.3)	STO-1, STO-5
Physical Impact (T4.3)	STO-1, STO-5
Socioeconomic Impact (T4.4)	STO-1, STO-5
Business Continuity Assessment (T6.2)	STO-1, STO-5
IMS & DSS (T6.7)	STO-1, STO-6
Standard Response Procedures (T6.3)	STO-1

6.2 Trans-event Scenario

6.2.1. Scenario 4: Given hazard, short-term planning

Scenario Description

Real time sensor data collected in the area of interest as well as public seismological information show that an earthquake took place.

IWAT/COP examines the collected information, along with the characteristics of the area and the consequences identified by the models in such cases and notifies the user if the earthquake is of such intensity that it has the potential to cause important issues.

The authorized User accesses the platform and is at once shown a map with flags where assets of the area and important IWW facilities are flagged in an easy to identify way (green, yellow and red) based on the level of expected damage.

The authorized User is focusing on the red flags, dispatching units and field personnel to confirm the damages. Then, the User is able to update the system, confirming or correcting the flags as new information is made available to him/her.

In cases where the area is not easily accessible, too large to inspect with field personnel, or the level of damage is not easy to assess based on the collected information, a qualified person is contacted to perform targeted UAV flights. Then, the results of these flights are transmitted to the authorized User as soon as they are available in order to correct the flags given by the models.

If damage is misclassified below an internal system threshold, an automated Bayesian updating process is triggered and the model is corrected based on the available information. If the damage misclassification is above this threshold, another qualified person is notified to proceed with a full retraining of the affected asset vulnerability models.

Rationale

The rationale behind this scenario is to showcase the usability of the IWAT/COP platform, and the demonstration of certain system modules that meet PLOTO's technical objectives, shown in Table 27.

Table 27: Rationale behind Scenario 4

PLOTO Module	Relevant STOs
IWAT platform (T6.1)	STO-1, STO-6
Common Operational Picture (T6.6)	STO-1, STO-6
Middleware and Data Fusion (T6.4)	STO-1, STO-8
Sensor Installations (T3.4)	STO-1
Multi - Hazard Model (T4.1)	STO-1, STO-2, STO-4
Physical Vulnerability Assessment (T4.2)	STO-1, STO-5
Risk Assessment Engine / Physical Impact (T4.3)	STO-1, STO-5
WP5 modules	STO-1
AI based decision making (T6.5)	STO-1, STO-4

6.3 Post-event Scenario

6.3.1. Scenario 5: No givens, Long term planning

Scenario Description

There is a newspaper article claiming that Europe is about to face severe droughts in the next 30 years. An authorized User, after reading that article uses the IWAT/COP and immediately assesses the droughts-forecast for the next 30 years. Then, the authorised user can compare the forecast with the data of the article in order to clarify whether the data of the two sources are in accordance.

The comparison may lead the authorised user to a decision on a potential update of the platform, with the inclusion of extra or updated data regarding the droughts. The user can use the IWAT/COP platform to employ possible drought scenarios and to test how these affect the future operational parameters of the IWW.

Rationale

The rationale behind this scenario is to showcase the usability of the IWAT/COP platform, and the demonstration of certain system modules that meet PLOTO's technical objectives, shown in Table 28.

Table 28: Rationale behind Scenario 5

PLOTO Module	Relevant STOs
IWAT platform (T6.1)	STO-1, STO-6
Common Operational Picture (T6.6)	STO-1, STO-6
Multi - Hazard Model (WP3)	STO-1, STO-2, STO-3, STO-4, STO-8
Risk Assessment Engine / Physical Impact (T4.3)	STO-1, STO-5
Socioeconomic Impact (T4.4)	STO-1, STO-5
Business Continuity Assessment (T6.2)	STO-1, STO-5
WP3 modules	STO-1, STO-8

7. Key Performance Indicators

PLOTO technical partners have identified the following Key Performance Indicators (Table 29) that will be used during the demonstrations to validate the success of the PLOTO project. At this point, it is important to mention that as the project evolves, the KPIs list might get updated.

Table 29: Description of all PLOTO KPIs

KPI No	KPI Name	KPI Description	Relevant Module	Relevant WP/Task	Relevant Partner
KPI1	Reliable quantification of climatic, hydrological and atmospheric stressors.	Identification and specialization of 20 climate indicators in connection with specific Impacts per use case. Downscaling and high-resolution mapping of climate impacts based on (minimum) two long-term climatic scenarios (baseline & worst case)**.: Yes or No (boolean)**	Multi Hazard Model (WP3 and T4.1)	WP3 WP4/T4.1	NTUA/AUTH
KPI2	Development of a forecasting module.	Improved skill scores (e.g., Critical Success Index (CSI) for deterministic and Brier score for probabilistic) of the hot-spot precipitation forecasts over different lead-times. **: Yes or No (boolean)**	WP3 modules	WP3	AUTH
KPI3	Development of advanced Remote-Sensing (RS) algorithms, multi-hazard modelling and AI tools for accurate IWW mapping and multi-hazard maps.	Novel learning methods for probabilistically detecting flaws in infrastructure in n-RT (just-in-time) processing complexity. We target to minimise both false positive and negative rates (target >25%, based on estimations from relevant projects, such as PANOPTIS, ZONESEC and RESIST). Novel learning methods for mapping land cover changes and detecting floods/landslides. Improved DInSAR methodologies.**: Yes or No (boolean)**	FDA (mFDA & sFDA)	WP5	NTUA
KPI4	Improved vulnerability analysis and resilience assessment,	Mean Absolute Percentage Error: **≤20% on all defined locations**	Digital Twin	WP6 / T6.8	EXUS

KPI No	KPI Name	KPI Description	Relevant Module	Relevant WP/Task	Relevant Partner
	including digital winning tools to simulate IWW.				
KPI5	Design of a COP including an enhanced visualisation interface and an IMS.	Quantifying risk of disasters & Pre-disaster situation: Hazard exposure, vulnerability, resilience, risk status, evacuation plans and modelling scenarios. Deliver data, info, products significantly sooner (30%) than COPERNICUS EMS.: **Yes or No (boolean)**	COP / IMS	WP6 / T6.6 and T6.7	STWS
KPI6	Improved efficiency of data.	Improved efficiency of marine traffic handling, decreased wait times, fewer disruption days due to natural hazards.: **Yes or No (boolean)**	N/A	WP2 WP7	N/A
KPI7	Establish long-term data platforms securing open, consistent data points.	Fuse all generated and collected data on both the PLOTO platform and in a common open repository (OpenAIRE, Zenodo, GitHub), achieving 100% availability for non-proprietary data, and at least 80% for proprietary (anonymized, non-confidential) data, while promoting a unified format for (IWW and non-IWW) infrastructure data representation and archiving.: **Yes or No (boolean)**	Multi Hazard Model (WP3 and T4.2)	WP2/T2.4 WP3/T3.5 WP4/T4.2 WP6/T6.4 and T6.8	SoReCC/NTUA
KPI8	Sensors / Services	Capability of the system for flexible and efficient integration of multiple services and sensors.: **Number of integrated services and sensors >=10**	Middleware	WP6/T6.4	RISA
KPI9	Sensors	Capability of the system to be able to accept, store and provide information from all PLOTO sensors.: **Connected sensors displayed in IWAT/COP**	Middleware	WP6/T6.4	RISA
KPI10	Data Processors	Capability of the system to handle multiple sources of data.: **Number of Data Processors (>=10)**	Middleware	WP6/T6.4	RISA

KPI No	KPI Name	KPI Description	Relevant Module	Relevant WP/Task	Relevant Partner
KPI11	Historical Data	The system should store data and metadata and allow historical look up and display (through the COP/IWAT).: **Yes or No (boolean)**	Middleware	WP6/T6.4	RISA
KPI12	Data updates on restoring communications	Capability of the system to restore the "lost" data upon communication recovery.: **Yes or No (boolean)**	Middleware	WP6/T6.4	RISA
KPI13	Data fusion	The system shall develop algorithms that combine information to improve accuracy.: **Yes or No (boolean)**	Middleware / Data fusion	WP6/T6.4	RISA
KPI14	Data fusion	The data fusion service should be able to combine alerts and provide a more concrete alarm (>1 alerts combined) to the operator.: **Yes or No (boolean)**	Middleware / Data fusion	WP6/T6.4	RISA
KPI15	Data fusion	Capability of the system to identify when a certain number of alerts illustrate incompatibility between location and/or time and generate a relevant alarm.: **Yes or No (boolean)**	Middleware / Data fusion	WP6/T6.4	RISA
KPI16	Data fusion	Capability of the data fusion service to merge multiple alarms that refer to the same event: **Yes or No (boolean)**	Middleware / Data fusion	WP6/T6.4	RISA
KPI17	Data fusion	The data fusion service will produce additional alarms for events that will be based on data concerning certain areas of interest.: **Yes or No (boolean)**	Middleware / Data fusion	WP6/T6.4	RISA
KPI18	Sensors / Services	Capability of the system to generate an alert when a sensor and/or service is no longer available: **Yes or No (boolean)**	Middleware	WP6/T6.4	RISA
KPI19	Water coverage/level	Capability of the system to compile data representation for water coverage/level assessment.**: Yes or No (boolean)**	PDDA	WP6/T5.4	UM
KPI20	Water coverage/level	Capability of the system to calculate water coverage changes.**: Yes or No (boolean)**	PDDA	WP6/T5.4	UM

KPI No	KPI Name	KPI Description	Relevant Module	Relevant WP/Task	Relevant Partner
KPI21	Water coverage/level	Capability of the system to calculate water level changes.: **Yes or No (boolean)**	PDDA	WP6/T5.4	UM
KPI22	Water coverage/level	Capability of the system to assess flooding/drought conditions.: **Yes or No (boolean)**	PDDA	WP6/T5.4	UM
KPI23	COP	Information from more that 3 data sources should be presented to the COP simultaneously. **Number of data sources: >3**	COP	WP6/T6.6	STWS
KPI24	COP	Number of assets depicted on COP map (without clustering) without flickering ~ 1000 objects **Number of objects on the map> 1000**	COP	WP6/T6.6	STWS
KPI25	COP	COP refresh updates -> Less than 5 seconds (assumes sufficient communication bandwidth in the field and the updated information is available to the middleware) **COP refresh rate: <5 seconds**	COP	WP6/T6.6	STWS
KPI26	IMS	IMS could support response plans with more than 50 actions steps **Number of action steps per plan: > 50**	COP	WP6/T6.7	STWS
KPI27	IMS	IMS could support the management of more than one incidents simultaneously. **Number of incidents: >1**	COP	WP6/T6.7	STWS
KPI28	IWAT	IWAT could support more than 50 users connected simultaneously. **Number of connected users: >50**	COP	WP6	STWS

Conclusions

Deliverable 2.2 “Definition of the requirements, use cases and system specifications – final version” is one of the three (3) Deliverables of WP2 and is related to Task 2.2 “Specification of system requirements, Use Cases, Scenarios Definition and KPIs” and Task 2.3 “Design of the overall system architecture”. In this report, the end-user requirements are refined and matched with the system requirements. Moreover, the PLOTO platform’s modules and data are defined, the PLOTO system high-level architectural specification is described and the use cases together with the relevant set of KPIs are presented. The architecture and KPIs might need to get updated, as the project evolves and becomes more mature.

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Appendix 1 - PLOTO system data

Table 30: Collection of PLOTO system data

	Provider			Data				Consumer	
	Provider Partner	Relevant WP	Relevant Task	Description	Type	File Format	File Size	Relevant WP	Consumer Module
1	The Flood Observatory	WP6	Asset and ml model prediction floods events	The Flood Observatory	hydrological time series data, GIS			WP6	
2	Pilot Site C	WP4	Flood area according to scenarios considered in Use Case C	Inundation modelling outcomes	numerical data	CSV		WP4	local storage
3	The European Space Agency (ESA)	WP6	High resolution assets	The European Space Agency (ESA)	satellite imagery data			WP6	
4	The United States Geological Survey	WP6	High resolution assets	The United States Geological Survey	elevation model and geospatial data			WP6	
5	Open Steet Map	WP6	High resolution assets	Open Steet Map	vector data of buildings and roads			WP6	
6	European Flood Database	WP6	ML model to predict floods events	European Flood Database	hydrological time series data	CSV		WP6	
7	Global Flood Monitoring System	WP6	ML model to predict floods events	Global Flood Monitoring System	hydrological time series data			WP6	
8	Specification of pilot use case	WP2	Specification of pilot use case	Hungarian River Information Services data (pannonris.hu)	text, numerical data, coordinates	NtS 4.0 xml, JSON		WP3	central repository
9	Specification of pilot use case	WP2	Specification of pilot use case	Hungarian hydrological official data (hydroinfo.hu)	text, numerical data, coordinates	NtS 4.0 xml		WP5	central repository
10	ICON-EU	WP2	Task 2.4	ICON-EU	numerical model data	grib2	8GB per site	WP3	local storage

Provider				Data				Consumer	
	Provider Partner	Relevant WP	Relevant Task	Description	Type	File Format	File Size	Relevant WP	Consumer Module
11	Pilot site weather station timeseries	WP2	Task 2.4	Pilot site weather station timeseries	text, numerical data, coordinates	CSV	5MB per site	WP3	middleware
12	Pilot site traffic data	WP2	Task 2.4	Pilot site traffic data	text, numerical data, coordinates	Excel, CSV	10MB per site	WP4	local storage
13	Euro-CORDEX	WP3	Task 3.1	Euro-CORDEX Episodic Periods	This dataset contains the data of episodic periods (days) identified from the results from an ensemble of climate model systems applying specific selection criteria.	CSV	~30 MB	WP3 WP4	middleware, local storage
14	Pilot site weather & hydro hazard scenarios	WP3, WP4	Task 3.1 & 4.1	Pilot site weather & hydro hazard scenarios	numerical data	HDF5 file	6GB per site	WP4	middleware
15	Pilot site wind simulation dataset	WP3	Task 3.3	Pilot site wind simulation dataset	numerical data	netCDF	3GB per site	WP3	middleware
16	Pilot site mesoscale model nowcasting timeseries	WP3	Task 3.4-3.5	Pilot site mesoscale model nowcasting timeseries	numerical data	netCDF or CSV	500MB per site	WP3	local storage
17	Daily nowcasting & forecasting mesoscale predictions	WP3	Task 3.6	Daily nowcasting & forecasting mesoscale predictions	text, numerical data, coordinates	geotiff, netcdf	10GB per site	WP3	middleware
18	Pilot site seismic hazard scenarios	WP4	Task 4.1	Pilot site seismic hazard scenarios	numerical data	HDF5 file	2GB per site	WP4	middleware
19	IWW asset fragility & vulnerability curves	WP4	Task 4.2	IWW asset fragility & vulnerability curves	text, numerical data	JSON & Excel file	1MB per site	WP4	local storage
20	Pilot site socioeconomic consequence dataset	WP4, WP6	Task 4.5, Task 6.2	Pilot site socioeconomic consequence dataset	text, numerical data	Excel or JSON & png	10MB per site	WP4 & WP6	middleware

Provider				Data				Consumer	
	Provider Partner	Relevant WP	Relevant Task	Description	Type	File Format	File Size	Relevant WP	Consumer Module
21	Pilot Sites	WP5	Task 5.2, Task 5.3, Task 5.4	Geographic Data	dataset	Shapefiles (.shp), TIFF (.tif), GeoTiFF (.tif), (.prj), (.dbf), (.shx), (.csv), (.json), (.xls)	500MB per pilot site	WP5	middleware
22	Pilot Sites	WP5	Task 5.2, Task 5.3, Task 5.4	Digital Elevation Models (DEMs)	raster dataset	(.tiff)	500MB per pilot site	WP5	middleware
23	Pilot Sites	WP5	Task 5.2, Task 5.3, Task 5.4, Task 5.5	UAV Flight Plans	report	(.json), (.lz), (.csv)	100MB per acquisition	WP5	middleware
24	Pilot Sites	WP5	Task 5.3, Task 5.4	SAR Sentinel 1A images	raster dataset	Sentinel product (.safe,.zip), JPEG2000(.jp2), GeoTIFF (.tif)	10TB (depending on the time span of the time series)	WP5	middleware
25	Pilot Sites	WP5	Task 5.3, Task 5.4	SAR Sentinel 1B images	raster dataset	Sentinel product (.safe,.zip), JPEG2000(.jp2), GeoTIFF (.tif)	10TB (depending on the time span of the time series)	WP5	middleware
26	Pilot Sites	WP5	Task 5.3, Task 5.4	Multispectral very high resolution images (World View, QuickBird)	raster dataset	JPEG2000(.jp2), GeoTIFF (.tif)	10TB (depending on the time span of the time series)	WP5	middleware
27	Pilot Sites	WP5	Task 5.3, Task 5.4	Multispectral (RGB) images	raster dataset	JPEG2000(.jp2), GeoTIFF (.tif), JPEG (.jpg)	1TB per acquisition	WP5	middleware
28	Pilot Sites	WP5	Task 5.3, Task 5.4	Hyperspectral images	raster dataset	ENVI data product (.hdr), PCIDSK (.pix), TIFF (.tif)	500GB per acquisition	WP5	middleware
29	Pilot Sites	WP5	Task 5.3, Task 5.4	Thermal images	raster dataset	TIFF (.tif)	100MB per acquisition	WP5	middleware

Provider				Data				Consumer	
	Provider Partner	Relevant WP	Relevant Task	Description	Type	File Format	File Size	Relevant WP	Consumer Module
30	Pilot Sites	WP5	Task 5.3, Task 5.4	GPS Measurements	dataset	(.txt), (.csv), (.dxf), (.dwg), (.pdf)	100MB per acquisition	WP5	middleware
31	Pilot Sites	WP5	Task 5.3, Task 5.4	3D representations	point cloud	(.ply), (.obj), (.wrl), (.dxf)	4-8GB per pilot site	WP5	middleware
32	Pilot Sites	WP5	Task 5.3, Task 5.4	3D representations	mesh (3D surface)	(.ply), (.obj), (.nxs), (.nxz)	4-8GB per pilot site	WP5	middleware
33	Spectral Library (SL)	WP5	Task 5.3, Task 5.4, Task 5.5	Spectral Library (SL)	report	(.pdf), (.doc), (.tiff), (.png), (.jpg)	200MB per pilot site	WP5	middleware
34	CV and ML framework (open source software)	WP5	Task 5.3, Task 5.4, Task 5.5, Task 5.6	CV and ML framework (open source software)	sofrtware			WP5	middleware
35	Pilot site regional and/or facility socioeconomic data	WP6	Task 6.8	Pilot site regional and/or facility socioeconomic data	text, numerical data	Excel file	1MB per site	WP2 & WP4	local storage
36	IWW exposure dataset	WP6	Task 6.8	IWW exposure dataset	text, numerical data, coordinates	Excel file & shapefile	100MB per site	WP2 & WP6	middleware