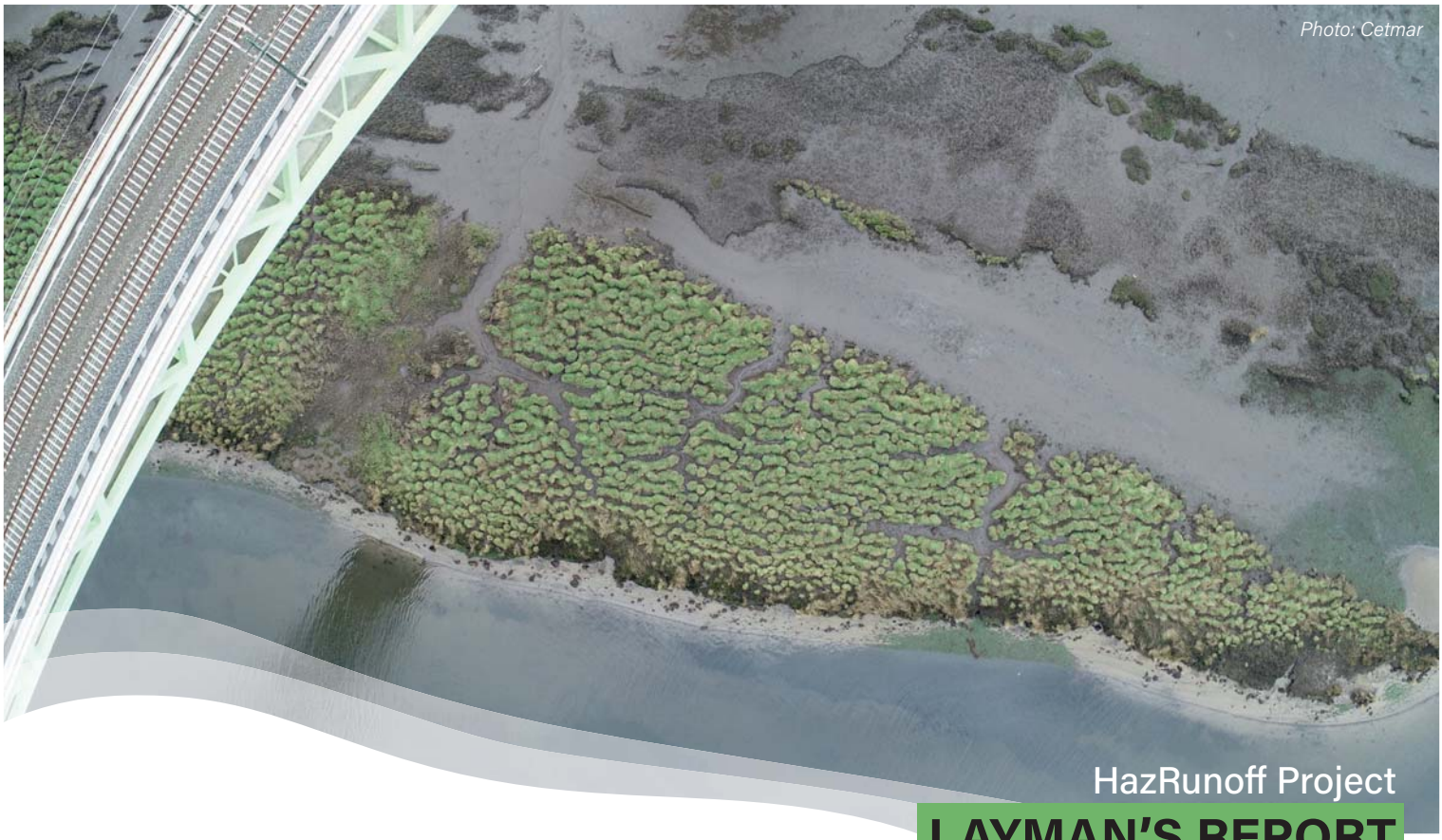


Photo: Cetmar

HazRunoff Project

LAYMAN'S REPORT

HAZRUNOFF

PROJECT

INTEGRATION OF SENSING AND MODELLING TECHNOLOGIES FOR EARLY DETECTION AND FOLLOW-UP OF HAZMAT AND FLOOD HAZARDS IN TRANSITIONAL AND COASTAL WATERS

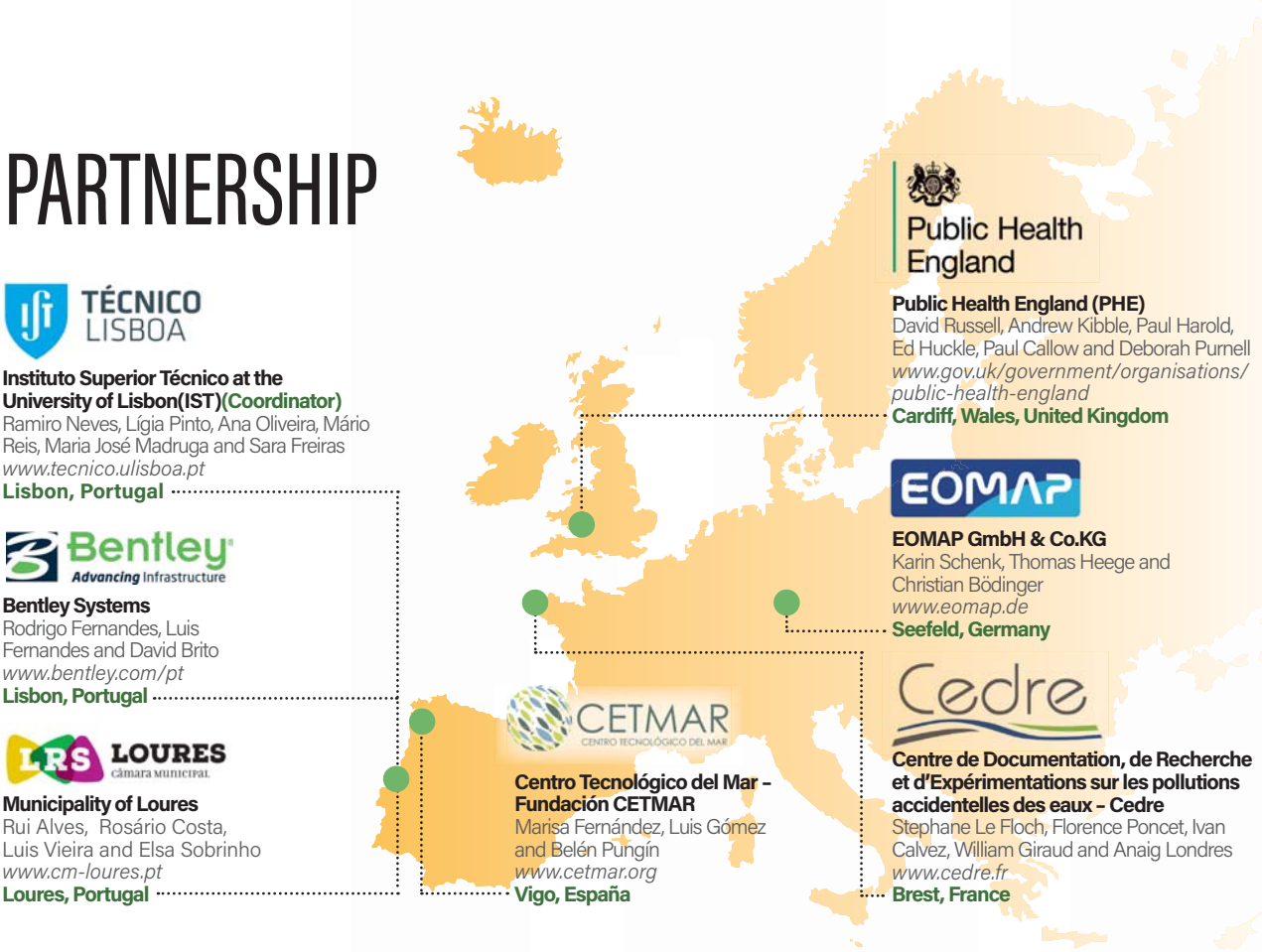
Funded by European Union Civil Protection and Humanitarian Aid

HazRunoff AT A GLANCE

Acronym: HazRunoff
Title: Integration of sensing and modelling technologies for early detection and follow-up of hazmat and flood hazards in transitional and coastal waters
Website: www.hazrunoff.eu
Duration: January 2018 – May 2020
Budget: 670,210.92 € (75% from EU)

Financing: European Commission's Humanitarian aid and Civil Protection Department (ECHO)
HazRunoff goal: To increase preparedness and response capacity on floods and pollutant hazards in rivers, transitional and coastal waters, through the development of a situational awareness and emergency response framework and associated tools, capable of supporting civil protection units and water pollution authorities.

PARTNERSHIP



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INDEX

Photo: Cetmar

FLOODS AND CONTAMINATION BY HAZARDOUS MATERIALS

Floods are the most common natural hazard by far (United Nations Office for Disaster Risk Reduction) and are the leading cause of deaths from disasters worldwide (Doocy *et al.*, 2013)[1].

According to the European Environment Agency (EEA) more than 3,500 flood events were registered in 37 European countries between 1980 and 2010, with data finding significant increases in flooding during this period.

Researchers have predicted that by 2050 material losses from floods will have increased fivefold and up to 17-fold by 2080. This increase is attributed to the rise in value of land around floodplains, the need for urban development and to a lesser extent climate change effects. The economic cost of hydrological events across the EU was about €166 billion from 1980 to 2017. This is around one-third of the losses from climatological events (NatCatSERVIVE database).

In response to the rising incidence of flooding, in 2007 the EU adopted the Floods Directive. It plays an important role in the Member States standardization of flood risk assessment and management processes using a five step approach:

The spread of hazardous materials is among the adverse consequences of floods, with the potential to increase their impact. Rising floodwaters can displace tanks and rupture pipelines, release chemical substances from water drainage systems, mines and tailing dams or damage commercial establishments and households that store chemicals. The mobilization of oil, chemicals, radioactive or floating objects, mainly in industrialized areas, can lead to adverse impacts in a variety of ways: toxic effects, injuries, environmental pollution, fires, explosions, etc.

Several limitations have been identified when encountering pollution in inland and transitional waters, characterized by variable hydrographic conditions, and with fast current velocities, all of which can change the behaviour of pollutants.

In this context, HazRunoff has tried to fill the knowledge and technology gaps around early warning & detection, follow-up, and early response to different or combined types of flooding and hazmat pollution in inland and transitional waters. Specifically the project has aimed to provide a comprehensive framework for planning and response integrating:

- *IN SITU* SENSING TECHNOLOGIES.
- AUTONOMOUS VEHICLES (DRONES) AND SATELLITE REMOTE SENSING.
- HOLISTIC HIGH-RESOLUTION MODELLING.
- OPERATIONAL TOOLS FOR SITUATIONAL AWARENESS AND CRISIS MANAGEMENT.
- IMPROVED CONTINGENCY PLANNING AND ADAPTED PROTOCOLS FOR RESPONSE AND COMMUNICATION.

[1] *Doocy S, Daniels A, Murray S, Kirsch TD. The Human Impact of Floods: a Historical Review of Events 1980-2009 and Systematic Literature Review. PLOS Currents Disasters. 2013 Apr 16. doi: 10.1371/currents.dis.f4de-b457904936b07c09daa98ee8171a.*

Source: European Court of Auditors.

PROJECT OBJECTIVES & LINES OF ACTION

Photo: Cedre

DATA ACQUISITION AND ANALYSIS

ADDRESSING EXISTING LIMITATIONS RELATED WITH DATA ACQUISITION AND MEASUREMENT REGARDING FLOODING AND POTENTIAL WATER CONTAMINATION.

PLANNING, TRAINING AND EXERCISING FOR RESPONSE

DEMONSTRATING PROTOCOLS, TRAINING ACTIVITIES AND EXERCISES FOR EFFICIENT PREPAREDNESS AND RESPONSE TO FLOODS AND HAZMAT CONTAMINATION.

SIMULATION AND FORECASTING OF FLOODS AND POLLUTANT DISPERSION

IMPLEMENTING AND VALIDATING MODELS FROM THE WATERSHED TO THE ESTUARY, USING INTEGRATION METHODS AND A DYNAMIC INTERFACE.

AWARENESS RAISING AND DISSEMINATION

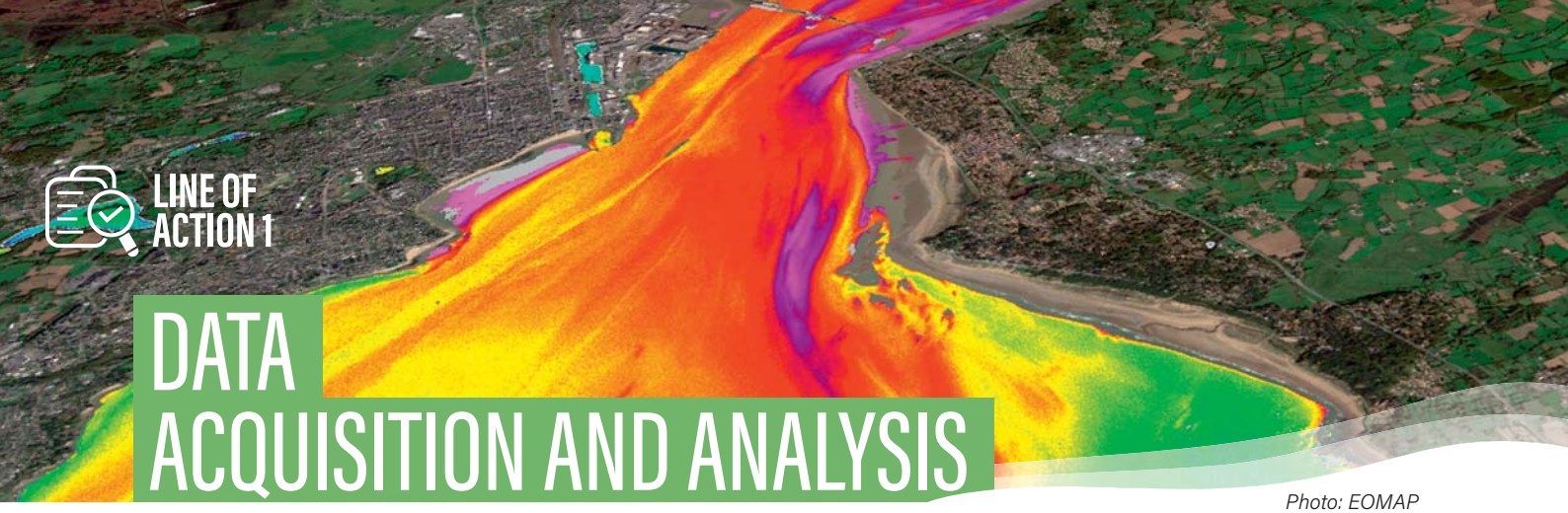
TRANSFERRING AND FACILITATING THE IMPLEMENTATION OF PROJECT OUTPUTS BY COMPETENT AUTHORITIES THROUGH PUBLIC EVENTS AND DISSEMINATION MATERIALS.

TOOLS FOR SITUATIONAL AWARENESS & EMERGENCY RESPONSE

FOCUSSING ON BUILDING USER-FRIENDLY WEB-BASED TOOLS AND MOBILE INTERFACES, HELPING TO PROMOTE IMPROVED COMMUNICATION DURING CRISIS MANAGEMENT AND TO ASSESS SOCIAL MEDIA TO INCIDENT ALERTING AND SITUATIONAL MONITORING.

PROJECT CASE STUDIES

HAZRUNOFF OUTCOMES WERE APPLIED IN FOUR DIFFERENT AREAS ACTING AS CASE STUDIES WITH THE POTENTIAL TO BE FURTHER REPLICATED IN OTHER AREAS.



LINE OF ACTION 1

DATA ACQUISITION AND ANALYSIS

Photo: EOMAP

RESPONSIBLE PARTNERS

EOMAP GmbH & Co.KG, PHE, IST, CETMAR and Cedre

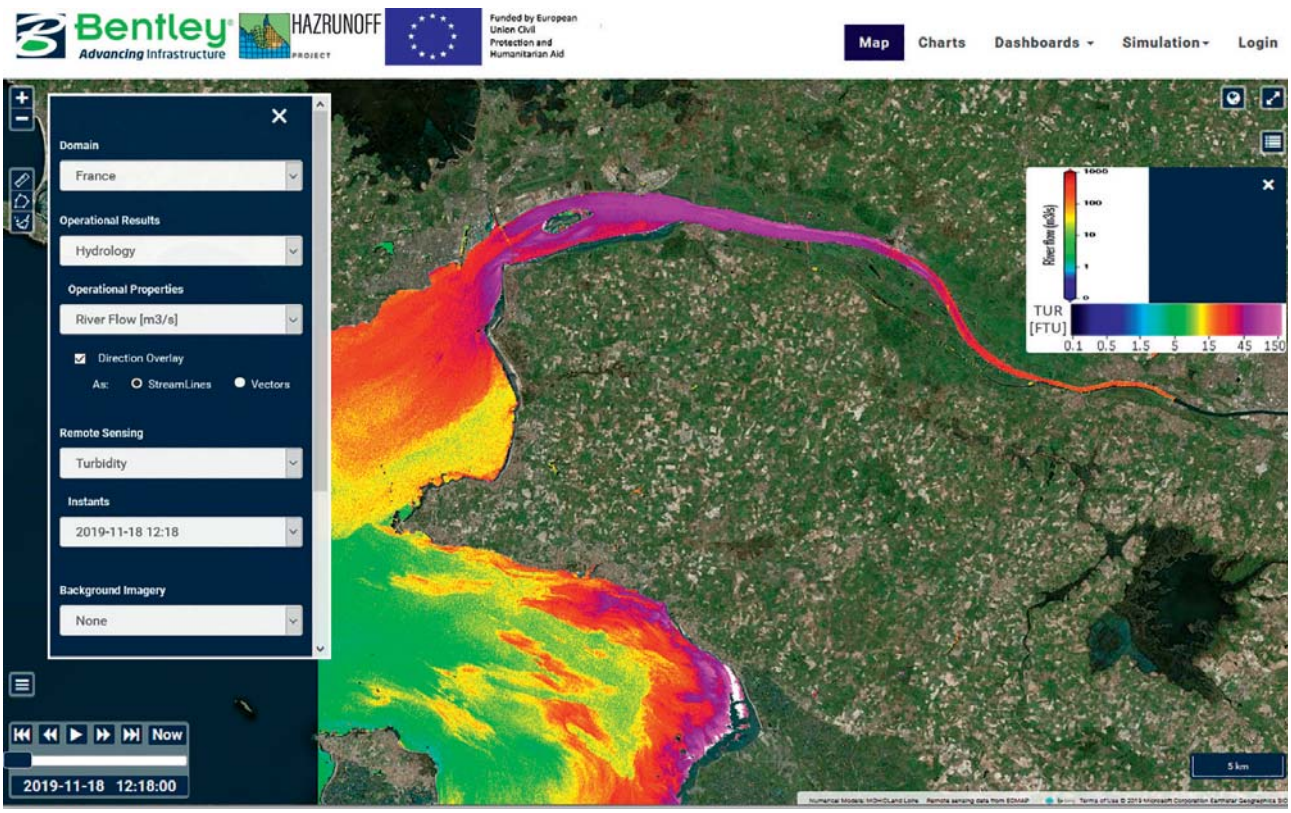
WHY IS NEAR REAL-TIME DATA FOR EMERGENCY RESPONSE NEEDED?

Flooding or water contamination events call for rapid actions to mitigate the consequences for both people and the natural environment. In order to set up adequate action plans, responders need to get information on areas at risk as soon as possible. However, traditional monitoring methods providing data through *in situ* tidal stations, human operated water quality measurements and aerial surveys provide local samples only. Assessing area-wide impacts on a larger scale requires more resources both in terms of personnel and time while smaller events may pass through the net of stationary observations and remain undetected. This calls for new techniques to be applied covering large areas in a timely fashion.

WEB SERVICES PROVIDING DATA ON WATER COVERAGE AND TURBIDITY BASED ON SATELLITE IMAGERY.

We used Satellite data from open-source high-resolution sensors of the European Space Agency (ESA) and the National Aeronautics and Space Administration of the U.S. (NASA) to set up area-wide observation systems. Based on this satellite imagery we designed fully operational processing chains, which can provide timely and accurate measurements for water properties and flooding occurrence. Using cloud-penetrating radar data, some water parameters can even be monitored during severe weather conditions. To make it possible for potential users to access this information, we established an online accessible interface through which the data are distributed and finally visualized within the **HazRunoff Platform**. Users can access the information on **Water Coverage** to see which areas are affected by flooding or analyse **Turbidity** as an indicator of suspended matter in the water column. Within the web portal, satellite products can be complemented by modelling results and other relevant parameters to support analyses **(fig.1)**.

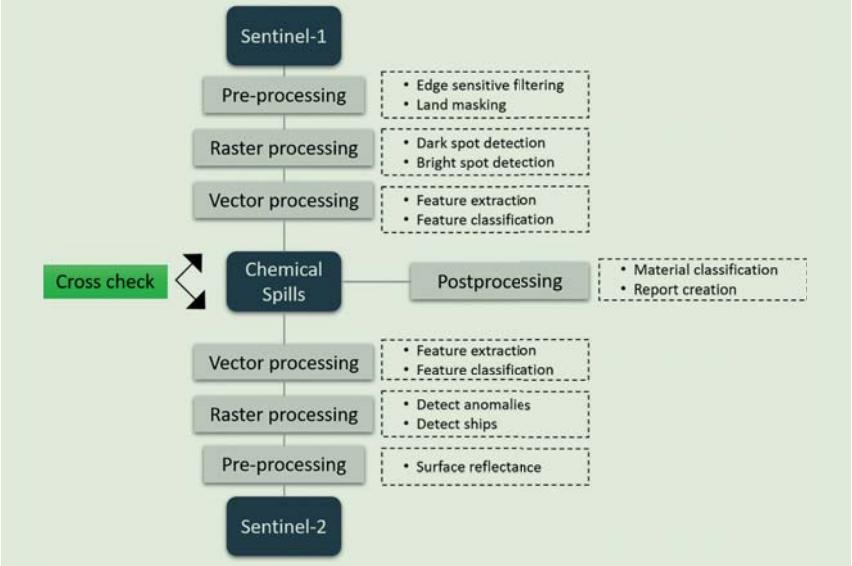
FIGURE 1 INTEGRATION OF SATELLITE IMAGES WITH MODELING RESULTS



LINE ACTION 1

Data acquisition and analysis

FIGURE 2 FRAMEWORK OF AN INTEGRATED SPILL DETECTION SYSTEM



FRAMEWORK FOR AN INTEGRATED CHEMICAL SPILL DETECTION SYSTEM

A framework for an operational oil and chemical spill detection system was developed together with project partners and maritime authorities. Processing combines information from optical and radar satellite sensors to improve reliability **(fig.2)**. Certain chemicals can also be detected by the sensors providing an indication of potentially hazardous substances. Information is presented in a standard report.

OPERATIONAL LIMITATIONS ASSOCIATED TO THE USE OF UNMANNED AERIAL VEHICLES (UAV) IN EMERGENCY RESPONSE CONTEXT.

Unmanned Aerial Vehicles (Drones) are becoming more and more widely used in society, including application to civil protection and pollution response. However, as with all new technologies, some challenges become apparent: the need for UAV-portable sensors for detecting chemical pollution, seamless and fast workflow between data collection and uploading to the cloud and visualization in situational awareness systems.

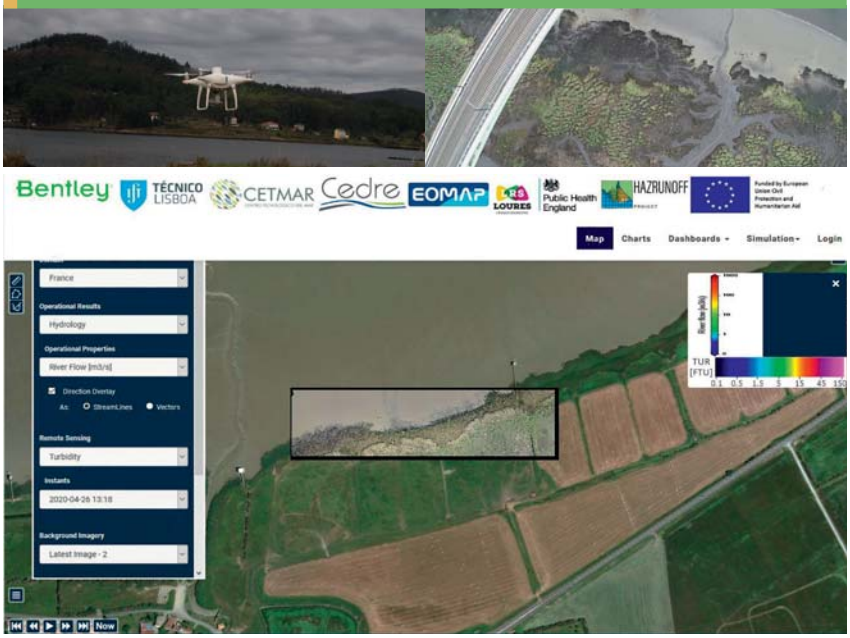
STANDARD WORKFLOW PROTOCOL FOR UAV DATA PROCESSING AND VISUALIZATION

HazRunoff prototyped the integration of UAV observation technologies with the situational awareness systems developed in the project **(fig.3)**, by establishing a standard workflow protocol: the data remotely obtained by the vehicles is processed and saved with a predefined GIS format (GeoTiff) and geographical projection (WGS84), and then uploaded to the HazRunoff cloud-based infrastructure becoming immediately accessible and readable by the HazRunoff operational systems. The integration of UAV data in HazRunoff operational system allows data analysis by the responders and contributes to a faster delimitation and visualization of the areas of concern. The same strategy can also be potentially used as initial conditions in on-demand simulations of pollutant transport and dispersion, or vice-versa (transport models can help target the area of interest to be observed by the UAVs).

RAPID RISK ASSESSMENT

When responding to a pollution incident in a waterway it is important to know how much of a pollutant is present and whether this poses a risk to health and / or the environment. However, to do this it is often necessary to review large amounts of results from monitors, requiring people and time, something that is not always possible during an incident. In fact, rapid risk assessments are

FIGURE 3 INTEGRATION OF UAV OBSERVATIONS IN THE SITUATIONAL AWARENESS SYSTEM



often undertaken in the initial stages of an event or incident when time, resources and data are often rather limited. When it comes to systematic risk assessments, the main activities are scheduled later in the event when more time and data are available, so in the early stages rapid simple approaches are needed.

An automated tool was developed for rapid review and assessment of water monitoring results, with potential risks visually displayed to assist timely decision making. Using commonly available software (Microsoft Excel), the tool takes data from the analyser and makes comparisons against health and environmental standards. It provides a structured and reproducible approach to risk assessment, supporting consistency in approach and providing outputs easily understood by the user **(fig.4)**. The tool has been trialled successfully with data for a range of pollution indicators using commercial water analyzers. The tool, together with instructions, test data and development report can be downloaded here. *http://www.hazrunoff.eu/detecting-sensing-and-sampling/*

FIGURE 4 VISUAL OUTPUTS FROM RAPID ASSESSMENT TOOL

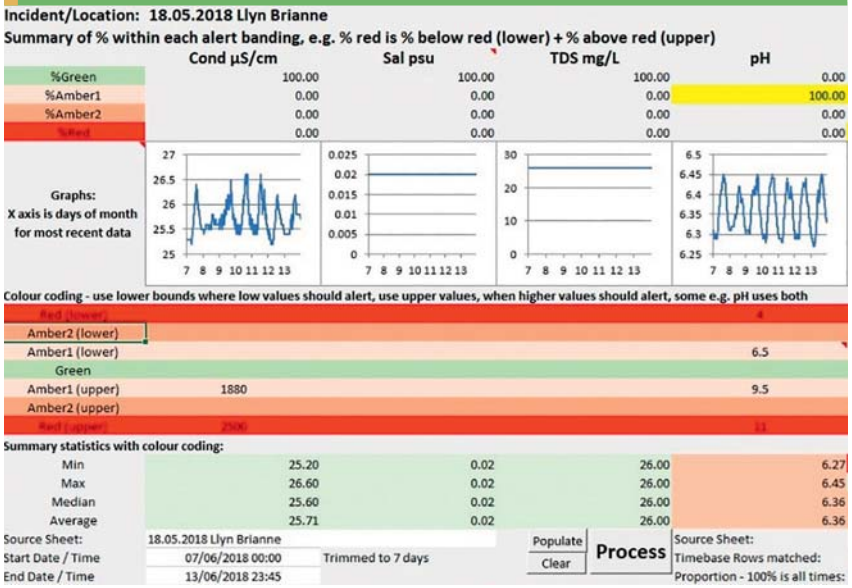


FIGURE 5 CHEMICAL TEST BENCH

TOWARDS UNDERSTANDING THE BEHAVIOUR AND FATE OF CHEMICALS

In recent years, CEDRE has carried out several projects aimed at better understanding the distribution of chemicals to the different compartments of the marine environment in the event of their accidental release at the water surface. A key deliverable of these research programs was the establishment of a database on Hazardous Noxious Substances (HNS). This database is an operational tool that makes it possible to provide modellers with precise data on the fate of HNS at sea (dissolution, evaporation, etc) obtained under experimental conditions that reflect realistic *in situ* environmental conditions. This database is accessible on the web site of the HNS-MS project (*https://www.hns-ms.eu/hnsdb*).

CHARACTERISATION OF CHEMICAL BEHAVIOUR AT SEA AND IN RIVERS

In the framework of HazRunoff, this database was updated and finalised to provide modellers with more information on the fate of chemicals at sea. For 13 substances, experimental testing was performed in the laboratory to define their fate under different environmental conditions (i.e. salinity and wind) using the "chemical test bench" of CEDRE **(fig.5)**.

Key results obtained:

- The evaporation of a chemical from a slick will be significantly influenced by the wind intensity: wind increases the evaporation rate.

- Even for fully soluble products, some may evaporate from the water column and produce a toxic and/or explosive gas cloud that will present a major risk to responders and the wider population.

These atypical behaviours are not systematically taken into account in modelling software because they are not known. HazRunoff has been able to supplement theoretical categorisation such as the Standard European Behaviour classification (SEBC) with new empirically derived data. ●

LINE OF ACTION 2

SIMULATION AND FORECASTING OF FLOODS AND POLLUTANT DISPERSION

Photo: Cetmar

RESPONSIBLE PARTNERS

IST, Bentley Systems International Ltd and Municipality of Loures.

WHAT ARE THE MAIN NEEDS TO BE ADDRESSED IN TERMS OF FLOOD MODELLING?

Most studies have focused on flooding and common pollution types associated to these events (e.g. oil spills), but have neglected the advantages of studying the water continuum between rivers, estuaries and coastal waters as a whole, and the possibility of using this integrated information to improve the prediction of pollutant transport and behaviour in water. An innovative and holistic model approach was thus implemented with integration of the different models (watershed, estuary and urban drainage) simulating the water continuum from the watershed to the sea.

WATERSHED, ESTUARINE AND METEOROLOGICAL MODELS FOR PROJECT PILOT STUDY AREAS

Modelling results for the four study areas are available from the HazRunoff web Platform (see modelling outputs 1 and 2 as examples). Users can access the information about current velocity, water temperature, salinity and water level for the estuarine models. For watershed models information about river flow and river velocity can be accessed and for the meteorological model wind velocity, air temperature and rainfall information are available.

URBAN FLOOD MODELS

High resolution urban flood models were prototyped in 2 case studies (Spain **(fig.6)** and Portugal), with one of them (Portugal) linking all of the modelling components: watershed, estuarine (coastal), meteorological, surface runoff and subsurface (stormwater and sewage) drainage network models. Obviously, this approach increases reliability in model results, helping emergency responders and decision makers related to flood resilience to make better decisions, based upon increased confidence in model results.

WATER CONTAMINATION

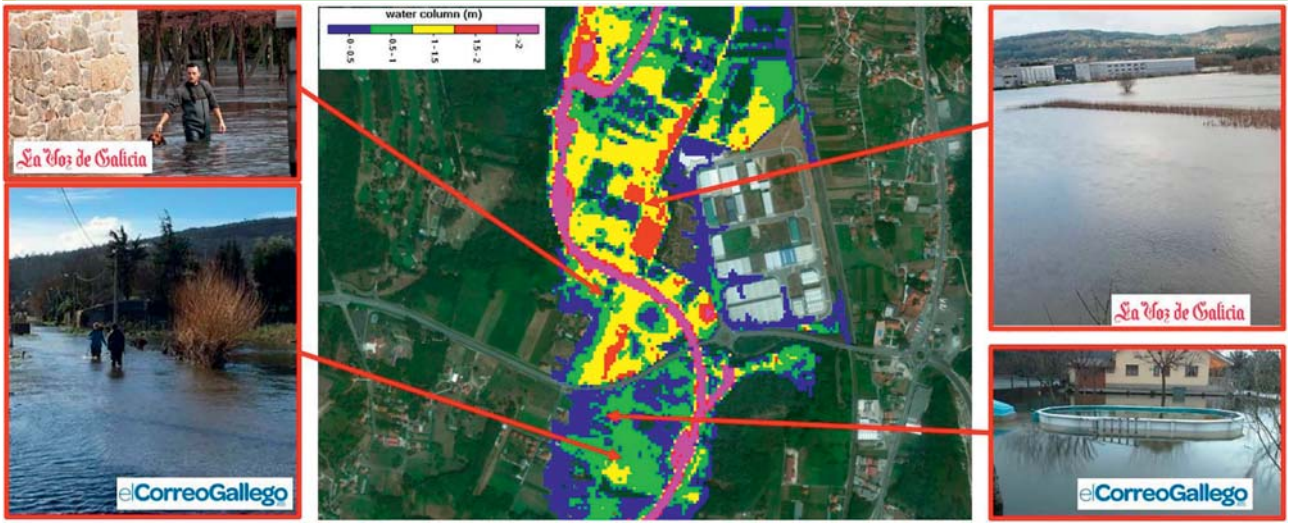
Since the above-mentioned hydro-meteorological improved model results are also directly ingested by the spill and contamination models used in HazRunoff, the decision-making process for water pollution is also significantly improved.

One example of such an application is the environmental risk analysis of radioactive contamination from nuclear powerplants. The holistic approach integrating different models allowed study of potential impacts from a hypothetical water leakage in a nuclear powerplant in Spain (Almaraz), and the potential impact in Portugal, between the Tagus River and the coastal area around Lisbon metropolitan area.

CHALLENGES REGARDING MODEL FORECAST

A number of challenges existed regarding the development of the models. Prediction of reservoir outflow and their integration in the watershed model represented one such challenge. In two of the four pilot cases studies there are dams located along

FIGURE 6 URBAN FLOOD MODEL IN PADRON, GALICIA (SPAIN) –WATER DEPTH ESTIMATION FROM FLOOD EVENT IN THE PAST (14 / 01 / 2016)



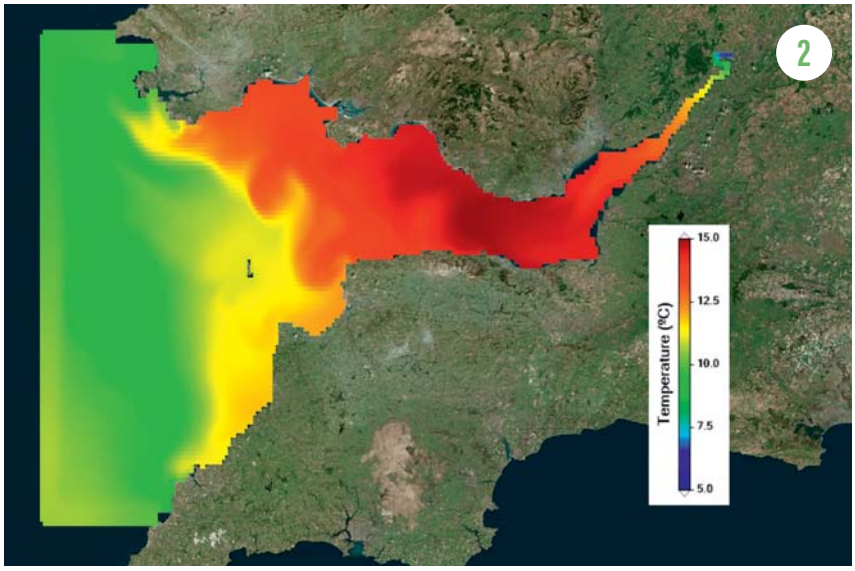
Simulation and forecasting of floods and pollutant dispersion

the rivers that control the amount of water flowing from the reservoirs. Forecasting this outflow is possible if you know the dam operation rules but normally this information is not publicly available.
Another such challenge was to model the dynamic flow exchange between natural channels (rivers), artificial channels (subsurface pipes from storm water or sewage pipes), and surface runoff. This capability is essential when studying urban flooding where artificial and natural drainage networks represent a significant role in the overland flow.

NOVEL FORECAST MODELLING APPROACH TO ESTIMATE THE RESERVOIR OUTFLOW

An Artificial Neural Network model was developed to predict the reservoir outflow using historical data from one of the dams located in the Ulla River (Spanish case study) to train and test the model. This approach was integrated with the watershed model (Portuguese and Spanish cases studies), contributing to a smarter and more reliable early warning system for flood management.

The ability of the model to simulate urban flooding was tested in the case of Sacavém (Portuguese case study), where in addition to the exchange between natural and artificial drainage there is also influence of coastal tides. For this case study watershed, estuary and urban drainage models were successfully integrated. ●



Lisbon downtown: urban flood model vs. images (2008 flood event)

IMAGES OF MODELLING OUTPUTS
1. *Loire estuary (France)*
2. *Severn estuary (United Kingdom)*

LINE OF ACTION 3

TOOLS FOR SITUATIONAL AWARENESS & EMERGENCY RESPONSE

Photo: CM Loures

RESPONSIBLE PARTNERS

Bentley Systems International Ltd. and Public Health England (PHE).

CHALLENGE AND NEEDS ADDRESSED IN TERMS OF PREPAREDNESS AND RESPONSE TOOLS

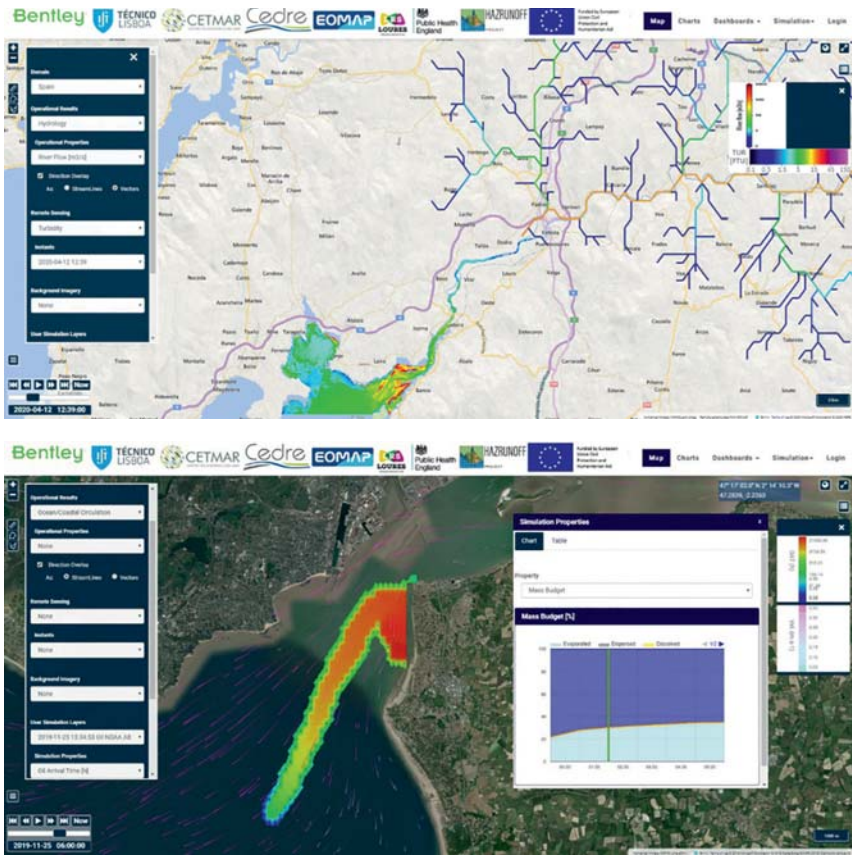
Emergency responders may easily get dispersed or overwhelmed by multiple static and dynamic / real-time data sources and the different tools that need to be taken into account to monitor and to respond to emergency situations. Consequently this can delay and complicate the decision-making process. The main challenge is to take advantage of all of the complex, various and disparate data sources generated in the project, and translate them into simple, reliable and fast decision support mechanisms. These tools should be sufficiently flexible for implementation and adaptation worldwide.

Our objective in HazRunoff was to support flood and hazmat emergency responders by building a bridge between the multiple data sources, the decision making, and ultimately, the communication and messaging to warn and inform the public and allay misconceptions. The main concept behind this approach was the implementation and prototyping of flood & water pollution resilience "digital twins". A digital twin of an infrastructure is a living digital simulation that brings all the data and models together and updates itself from multiple sources to represent its physical counterpart. The digital twin, continuously maintained and easily accessible at any time, provides an early insight into potential risks to both the environment and to citizens induced by floods and water pollution. Efficient and faster data-driven decision making of emergency responders is then promoted through powerful yet user-friendly web-based tools and mobile-friendly interfaces, combining and collating multiple data sources (including social media and "big data" for alerting), and at the same time, promoting better and smoother communication during management of the crisis.

HAZRUNOFF ONLINE PLATFORM FOR AWARENESS AND RESPONSE

Based on the aggregation of data from *in situ* sensing, remote sensing, advanced forecasting systems and risk management, a comprehensive and state-of-the-art web interface for supporting situational awareness and response to floods and hazmat was developed **(fig.7)**. The digital twin was prototyped through a cloud-based and mobile-friendly cross-platform. The online system is composed of a flood and water pollution early warning system (capable

FIGURE 7 WEB INTERFACE FOR SUPPORTING SITUATIONAL AWARENESS AND RESPONSE



of sending periodic reports or event-triggered notifications when individual or combined parameters are measured and/or forecasted), real-time dynamic maps and dashboards for hydro-meteorological and water contamination situational awareness, and an advanced on-demand pollutant dispersion system for the tailor-made and on-the-fly simulation of fate and behaviour of objects and substances released in water or air. With this platform, a responder can visualize *in situ* data measurements, modelling results, satellite-derived data, as well as ortho-photo images obtained for instance from UAV's (and visualized in near-real time after upload), allowing the user to combine multiple data layers on the same digital map.

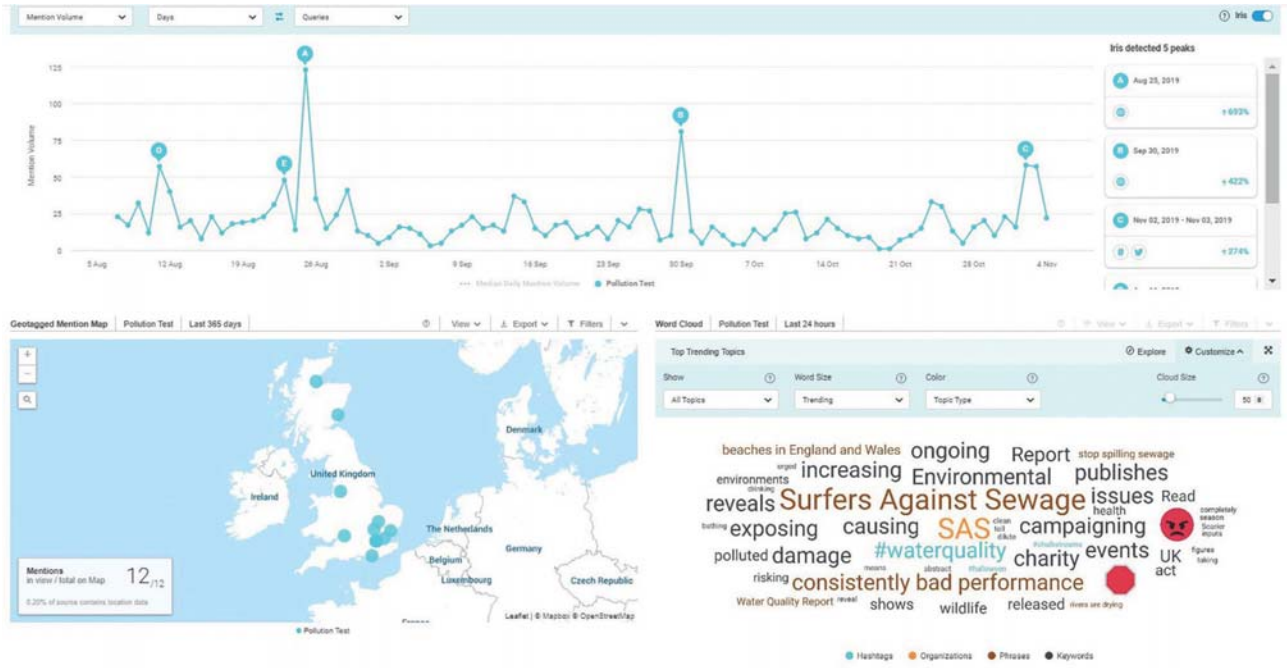
The system has been implemented in 4 different pilot sites.

In addition, the integration of social media analytics was also tested as a potential tool for preparedness and response purposes.

STUDY ON SOCIAL MEDIA AS AN ALERTING TOOL

Social media is known to help during incidents both in terms of communicating and sharing messages and advice and in monitoring and detecting incidents and events. It has been widely used in a variety of other emergency applications such as around disease outbreaks and tracking wildfires. Firstly, previous pollution and flooding incidents were used to identify the most common types and key words linked to them. These key words were then used in a 3-month trial to search for incidents across the UK using commercial and free internet search tools **(fig.8)**. Results found that scanning social media can provide a useful addition to the alerting process, particularly for identifying smaller localised incidents, but is best used in conjunction with existing conventional alerting techniques. The results also demonstrated the impacts of warning and informing messages to the public and the usefulness of monitoring responses to these during an incident.
Full details of the study can be downloaded here: *http://www.hazrunoff.eu/tools-for-situation-awareness-emergency-response/*. ●

FIGURE 8 IMAGE OF SOCIAL MEDIA MONITORING DASHBOARD



LINE OF ACTION 4

PLANNING, TRAINING & EXERCISING FOR RESPONSE

Photo: Cedre

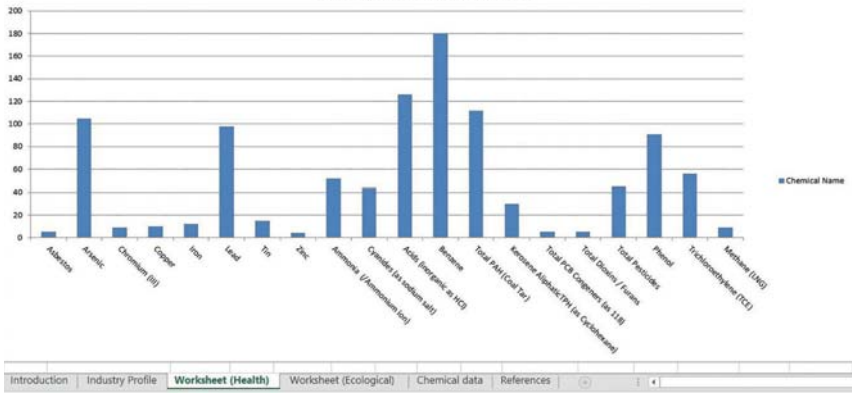
RESPONSIBLE PARTNERS

Cedre, PHE and IST.

WHAT IS NEEDED IN TERMS OF TRAINING AND EXERCISE?

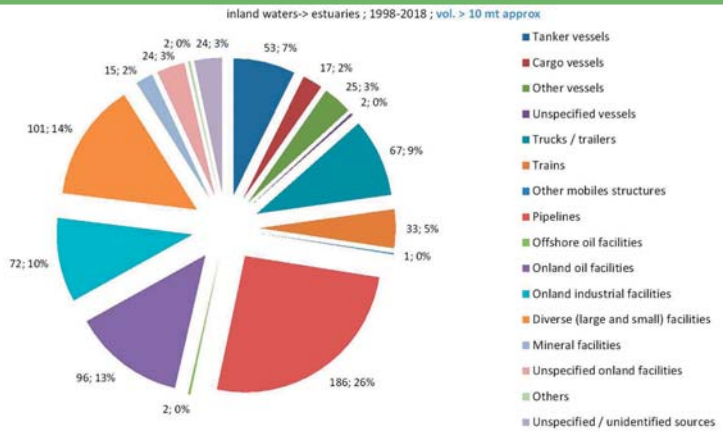
Optimising response to flooding or hazmat spills in waterways and transitional waters often requires special considerations. Availability of effective contingency planning and decision-making tools as well as trained teams is critical. Knowledge of specific hazards in an area, and the characteristics of incidents occurring in these environments can help to better identify potential risks and response strategies. Furthermore, in transitional waters, the high velocity of currents, among other environmental characteristics, often requires adaptation of response techniques as widely used conventional equipment, such as booms, are not always appropriate. Finally, practical training and guidance for key staff is important to provide awareness of these issues and of the best use of available specific approaches. To support response teams and improve preparedness and response to flood events and hazmat incidents associated with inland and transitional waters, we developed risk management tools and response protocols, considering past incidents and hazards, environmental specificities for estuaries and available response equipment. We also prepared training materials specially adapted to the particular hydrographic conditions and current velocities in rivers and estuarine areas.

FIGURE 9 PRIORITISATION - HAZARD TO HEALTH



Output from hazard prioritization tool.

FIGURE 10 DISTRIBUTION (N, %) OF SPILLS (ALL POLLUTANTS) BY TYPE OF



HAZARD PRIORITIZATION METHODOLOGY AND TOOL

To enhance preparedness, a process was developed to prioritise pollution hazards from past and present coastal industrial infrastructure within areas that may be affected by events such as flooding and coastal erosion.

The four-step methodology involves scoping, hazard identification, review of local receptors (human and environmental) and prioritisation using a risk-based approach. An automated tool developed by the project team aids the process calculating the relative risk of identified hazards, prioritising those requiring more detailed review and ultimately aiding contingency planning by helping to inform modelling, monitoring and training approaches **(fig.9)**. A case study from the Bristol Channel region of the UK illustrates the process.

REVIEW OF PAST INCIDENTS

A desktop study on past incidents in transitional waters was conducted to identify their specific characteristics. This analysis was based on a review of incidents for oil and chemicals recorded in the Cedre database over the past 10 years and by review of literature from international agencies such as Oil Spill Response, International Maritime Organization, European Maritime Safety Agency. The result of this analysis **(fig. 10 and 11)** is presented in a report available on the project website.

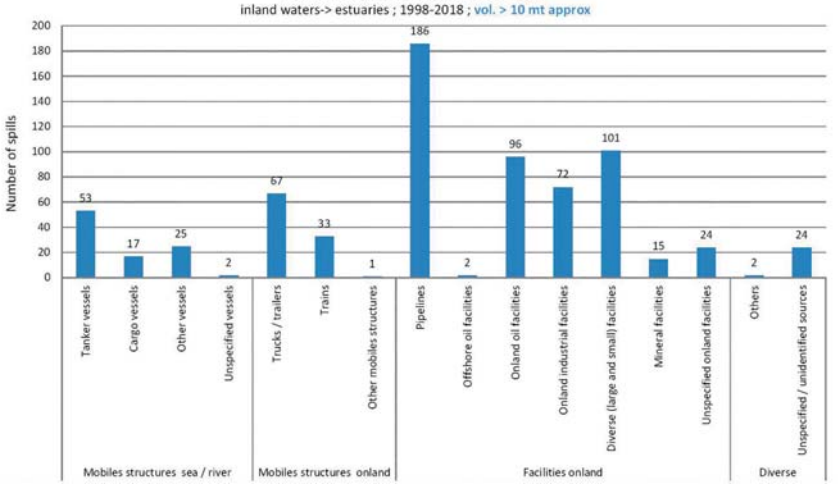
MAPPING SPECIFICITIES OF ESTUARY ENVIRONMENTS

Estuary environments have a high level of complexity due to their hydrodynamic parameters as well as their importance for wildlife and natural habitats. These specificities must be considered before response strategies can be defined. The sensitivity of habitats to oil or hazmat contamination depends on their possibility to be submerged by contaminated waters or floating pollution as well as the intrinsic sensitivity of species present. In the Loire estuary pilot area, sensitivity mapping was performed using existing submersion and vegetation maps and results of past oil contamination impact studies providing a comprehensive map of the estuary and a methodology that can be applied to other regions.

ANALYSIS OF AVAILABLE RESPONSE EQUIPMENT

During response, if containment and pumping strategy is chosen, the use of conventional booms is not always appropriate to transitional waters.

FIGURE 11 DISTRIBUTION (N) OF SPILLS BY TYPE OF SOURCES



Clearly, responders need to adapt their strategy to the specificities of estuary areas, and not only to the chemical nature of the pollution, in order to select the most appropriate equipment **(fig.12)**. An operational report has been written, detailing the uses and limitations of conventional booms in such environments as well as collating and reviewing new equipment designed to contain and collect floating pollutants in strong currents. In addition, the report presents a review of equipment trials implemented in the Loire estuary to assess their performance.

DEVELOPMENT OF TRAINING ACTIVITIES

A two day bespoke training course has been prepared for key staff involved in emergency response to oil and chemical spills. The course provides practical training and guidance in preparing for response to HNS and oil incidents in rivers, estuaries and bays, taking into consideration the specific challenges posed by such environments. In addition, all presentations and training materials are available from the HazRunoff website for wider audiences including an outline programme to implement the 2 day course. ●

FIGURE 12 EXAMPLE OF A COLLECTION SYSTEM WITH DEFLECTORS AND COLLECTION POOL TOWED BY ONE VESSEL EQUIPPED WITH A PARAVANE

LINE OF ACTION 5

AWARENESS RAISING & DISSEMINATION

RESPONSIBLE PARTNERS

CETMAR.

HazRunoff was a result-oriented project aiming to deliver tangible outcomes among a broad audience that includes competent authorities and associated agencies who deal with environmental and public health emergencies involving floods and hazmat pollution in the participating countries and beyond the partnership.

All project partners contributed to the identification of end users and stakeholders at international, national or/and regional level and kept a close interactions and fluent communication with all the potential beneficiaries, principally civil protection services, emergency responders, water management institutions, modellers, entities working on remote sensing, contingency planners, environmental managers and scientists. All these organisations were informed about / involved (when feasible) in the project activities and were the target of dissemination actions so they could benefit from the project outputs.

To facilitate the implementation of the project results and raise awareness amongst communities in general, HazRunoff used different methods for disseminating outputs and contacting potential stakeholders.

A user-friendly project website (http://www.hazrunoff.eu/) was designed to facilitate the accessibility to the main project outcomes (fig.13). In addition, twitter social media account (@hazrunoff) was used for sending short online messages on project news or other relevant information within the project scope. Six issues of the project Newsletter were published updating project developments and progress and providing information about partner organizations and their role in emergency response and in the project.

To transfer HazRunoff outcomes to local stakeholders, 4 Workshops were organized along 2019 and 2020 in the four countries where pilot areas had been selected (Spain, UK, France and Portugal), using the relevant local case study as an example to discuss project outputs and their application. Because of the COVID 19 Pandemic, the Workshop in Portugal was run as a virtual web based event.

- **Vigo. Spain. February, 1st 2019**
- **Cardiff. Wales. June, 20th 2019**
- **Saint Nazaire. France. November, 27th 2019**
- **Loures. Portugal. May, 27th 2020**

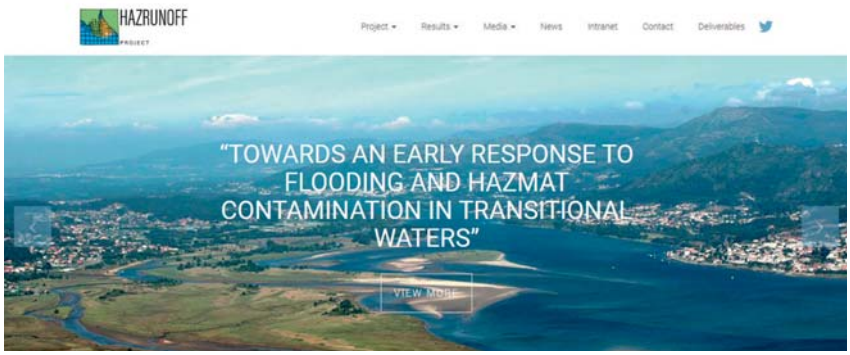
The Workshop agendas included demonstrations of HazRunoff tools developed in the project framework and their potential application to the stakeholders needs.

In addition, partners participated in external conferences and forums relevant to the objectives of the project. HazRunoff progresses and outcomes were presented and experience and knowledge were exchanged with researchers and stakeholders who dealt with water pollution and floods.

To keep wider audiences abreast of HazRunoff activities we produced leaflets and posters illustrating project basics as well as this Layman's report that summarizes the outputs and actions carried out throughout the lifetime of the project. Digital versions of these materials are available from the project website.

We consider capitalization as a key element that goes beyond dissemination and that aims to ensure the transferability and continuity of the project's results. All of the project partners contributed and will keep contributing to the capitalization of HazRunoff results by developing coordinated actions to promote the uptake and applicability of project outputs by key stakeholders and end users. This will ensure a tangible impact of HazRunoff after the project has ended and that its results are transferred to other European regions, Member States and stakeholders beyond the partnership. ●

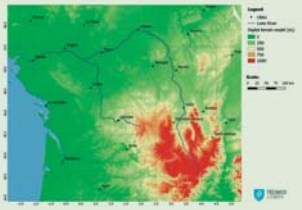
FIGURE 13 WEBSITE HOMEPAGE



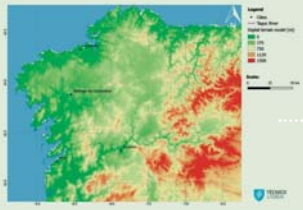
CASE STUDIES

PROJECT OUTCOMES WERE APPLIED IN FOUR DIFFERENT CASE STUDIES INVOLVING TYPICAL ZONES IN EUROPE WITH IMPORTANT RIVERS AND TRANSITIONAL WATERS.

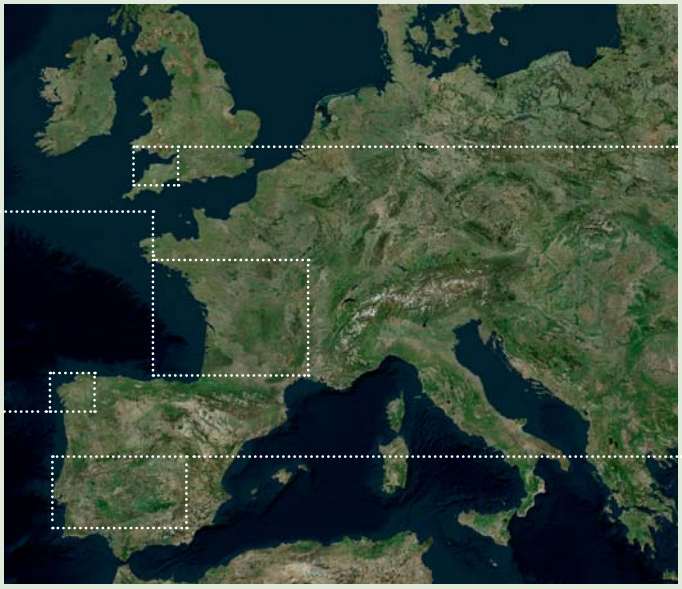
Photo: Cedre



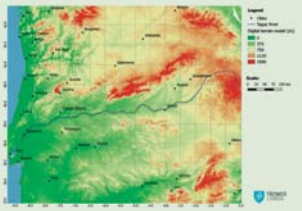
FRANCE Loire River and its estuary.



SPAIN Ulla-Sar Rivers, their estuary and middle-inner part of Ría of Arousa.



UK Severn River and its estuary.



PORTUGAL Tagus River and Tagus estuary including Loures Municipality.

The four pilot areas have strong socio-economic relevance, with several water-based activities (fishing, tourism, ports, etc.). They are directly associated with flood risks and potential hazmat incidents, due to the presence of industries – including nuclear power plants (Loire and Tagus rivers).

DEPENDING ON THE TYPE OF INCIDENT TO BE HANDLED DIFFERENT MODEL SCALES WERE USED TO STUDY THE AREAS:

1.

HIGH RESOLUTION MODEL SCALE ALLOWED DETAILED STUDY OF DIFFERENT TYPES OF FLOOD EVENTS (COASTAL, RIVER OR URBAN FLOODING) PUTTING A SPECIAL FOCUS ON URBAN AREAS THAT COULD BE AFFECTED.

2.

OIL AND CHEMICAL SPILLS WERE STUDIED USING MID-RESOLUTION MODELS, SINCE THESE TYPES OF INCIDENTS MOSTLY OCCUR AT RIVER AND ESTUARY SCALES.

3.

LOWEST RESOLUTION MODELS WERE USED FOR THE ASSESSMENT OF NUCLEAR CONTAMINATION COVERING LARGE AREAS. THIS SCALE WAS ONLY CONSIDERED IN THE CASES OF FRANCE AND PORTUGAL (INVOLVING THE NUCLEAR POWER PLANTS INSTALLED IN CHINON AND ALMARAZ RESPECTIVELY).

In these four countries local competent authorities, some of them part of the project advisory board, were informed in detail about the main features of HazRunoff and regular contact was maintained during the project lifetime. Their valuable support in each area of study allowed us to advance aspects of particular relevance for the achievement of project milestones:

- **Exchange** of information regarding the forecasting systems and tools for flooding risk management available for these basins and transitional waters.
- **Support** in the definition of the case studies in each region according to common previously defined criteria.
- **Provision** of valuable information about general characteristics of the area (topography, digital terrain models, dams, land uses…), historical pollution incidents and relevant monitoring data (river levels, flow rate, water quality….).
- **Identification** of the specific needs and priorities of local authorities in terms of early warning, detection and follow-up of flood events and hazmat contamination in inland and transitional waters.
- **Validation** of the project approach specifically adapted to each pilot case, testing the potential and limitations of the operational decision support tools developed.
- **Participation** in coordination meetings and workshops organized in the framework of the project.

IMPACT OF HAZRUNOFF

THE PROJECT HAS DELIVERED A SET OF MATERIALS AND TOOLS TO HELP IMPROVE THE PROCESS OF EARLY WARNING, EARLY DETECTION, FOLLOW-UP AND RESPONSE TO FLOODS AND HAZMAT CONTAMINATION IN TRANSITIONAL WATERS. ALL OF THESE TOOLS ARE AVAILABLE ON HAZRUNOFF WEBSITE.

It is hoped that these outcomes will contribute to

1. INCREASED PREPAREDNESS AND KNOWLEDGE ON MULTIPLE TYPES OF FLOODS

2. FASTER DETECTION OF HAZMAT INCIDENTS, BOTH OIL AND CHEMICAL, IN TRANSITIONAL WATERS

3. A MORE EFFICIENT FOLLOW-UP OF POLLUTION INCIDENTS IN TRANSITIONAL WATERS

4. INCREASED AWARENESS ON POTENTIAL MARITIME POLLUTION ORIGINATED IN INLAND AND ESTUARINE WATERS

5. STRONGER AND SAFER CAPACITY FOR IDENTIFICATION AND MONITORING OF CONTAMINATED AREAS

6. IMPROVED CONTINGENCY PLANNING

7. INCREASED AWARENESS AROUND HAZARD IDENTIFICATION AND RISK PERCEPTION

8. IMPROVED KNOWLEDGE OF CHEMICAL PROPERTIES AND BEHAVIOUR OF POLLUTANTS IN TRANSITIONAL WATERS

9. IMPROVED KNOWLEDGE AND AWARENESS AROUND MULTIPLE HAZARDS VIA BESPOKE TRAINING MATERIALS, COURSES AND EXERCISING

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