D942.21 – REPORT ON THE APPLICATION OF THE SOLUTIONS TO TRIAL 1

SP94 - TRIALS

JULY 2018 (M51)

This project has received funding from the European Union's 7th Framework Programme for Research, Technological Development and Demonstration under Grant Agreement (GA) N° #607798

Project information

Project Acronym:	DRIVER+
Project Full Title:	Driving Innovation in Crisis Management for European Resilience
Grant Agreement:	607798
Project Duration:	72 months (May 2014 - April 2020)
Project Technical Coordinator:	TNO
Contact:	coordination@projectdriver.eu

Deliverable information

Deliverable Status:	Final
Deliverable Title:	D942.21 – Report on the application of the solutions to Trial 1
Deliverable Nature:	Report (R)
Dissemination Level:	Public (PU)
Due Date:	July 2018 (M51)
Submission Date:	04/09/2018
Sub-Project (SP):	SP94 - Trials
Work Package (WP):	WP942 - Solutions in trials
Deliverable Leader:	GMV
Reviewers:	Christoph,Ruggenthaler, AIT Maurice, Sammels, XVR Hector, Naranjo, GMV
File Name:	DRIVER+_D942.21_Report on the application of the solutions in Trial 1.docx
Version of template used:	V2.0 – June 2018

Revision Table

Issue	Date	Comment	Author
V0.1	13/06/2018	Initial first version.	Raul, Valencia, GMV WP Leader in GMV
V0.2	11/07/2018	Second version with updates according to reviewers' comments and including contribution from DRM solution provider.	Raul, Valencia, GMV WP Leader in GMV
V0.3	27/07/2018	Third version with updates according to reviewers' comments and including contribution from 3Di solution provider and Introduction and Conclusion section.	Raul, Valencia, GMV WP Leader in GMV
V0.4	17/08/2018	Fourth version with updates according to reviewers' comments.	Raul, Valencia, GMV WP Leader in GMV
V0.5	22/08/2018	Fifth version with updates according to reviewers' comments.	Raul, Valencia, GMV WP Leader in GMV
V0.6	28/08/2018	Final check and approval for submission	Tim Stelkens-Kobsch, DLR, Quality Manager
V0.99	29/08/2018	Final check and approval for submission	Peter Petiet, TNO, Project Director
V1.0	04/09/2018	Final check and submission to the EC	Francisco Gala, ATOS

The DRIVER+ project

Current and future challenges, due to increasingly severe consequences of natural disasters and terrorist threats, require the development and uptake of innovative solutions that are addressing the operational needs of practitioners dealing with Crisis Management. DRIVER+ (Driving Innovation in Crisis Management for European Resilience) is a FP7 Crisis Management demonstration project aiming at improving the way capability development and innovation management is tackled. DRIVER+ has three main objectives:

1. Develop a pan-European Test-bed for Crisis Management capability development:
   a. Develop a common guidance methodology and tool, supporting Trials and the gathering of lessons learnt.
   b. Develop an infrastructure to create relevant environments, for enabling the trialling of new solutions and to explore and share Crisis Management capabilities.
   c. Run Trials in order to assess the value of solutions addressing specific needs using guidance and infrastructure.
   d. Ensure the sustainability of the pan-European Test-bed.
2. Develop a well-balanced comprehensive Portfolio of Crisis Management Solutions:
   a. Facilitate the usage of the Portfolio of Solutions.
   b. Ensure the sustainability of the Portfolio of Solutions.
3. Facilitate a shared understanding of Crisis Management across Europe:
   a. Establish a common background.
   b. Cooperate with external partners in joint Trials.
   c. Disseminate project results.

In order to achieve these objectives, five Subprojects (SPs) have been established. **SP91 *Project Management*** is devoted to consortium level project management, and it is also in charge of the alignment of DRIVER+ with external initiatives on crisis management for the benefit of DRIVER+ and its stakeholders. In DRIVER+, all activities related to Societal Impact Assessment are part of SP91 as well. **SP92 *Test-bed*** will deliver a guidance methodology and guidance tool supporting the design, conduct and analysis of Trials and will develop a reference implementation of the Test-bed. It will also create the scenario simulation capability to support execution of the Trials. **SP93 *Solutions*** will deliver the Portfolio of Solutions which is a database driven web site that documents all the available DRIVER+ solutions, as well as solutions from external organisations. Adapting solutions to fit the needs addressed in Trials will be done in SP93. **SP94 *Trials*** will organize four series of Trials as well as the final demo. **SP95 *Impact, Engagement and Sustainability***, is in charge of communication and dissemination, and also addresses issues related to improving sustainability, market aspects of solutions, and standardization.

The DRIVER+ Trials and the Final Demonstration will benefit from the DRIVER+ Test-bed, providing the technological infrastructure, the necessary supporting methodology and adequate support tools to prepare, conduct and evaluate the Trials. All results from the Trials will be stored and made available in the Portfolio of Solutions, being a central platform to present innovative solutions from consortium partners and third parties, and to share experiences and best practices with respect to their application. In order to enhance the current European cooperation framework within the Crisis Management domain and to facilitate a shared understanding of Crisis Management across Europe, DRIVER+ will carry out a wide range of activities. Most important will be to build and structure a dedicated Community of Practice in Crisis Management, thereby connecting and fostering the exchange of lessons learnt and best practices between Crisis Management practitioners as well as technological solution providers.

Executive summary

This deliverable has been elaborated as part of the work in **Task 942.2 *Applying solutions in the trials***, related to the work package **WP942 *Solutions in trials***. Its main objective is to report on the application of solutions to Trial 1. Concretely, it describes the activities carried out by the corresponding solution providers in order to have their solutions ready to be used in Trial 1, and provides an overview on how the solutions were used during the Trial 1 execution.

The specific objectives of the Trial were as follows:

- To simulate coordinated actions at the local, regional, national and international level with the purpose to counteract disaster effects.
- To test selected solutions for applicability.
- To evaluate the Test-bed.
- To validate the DRIVER+ methodology.

The scenario which provided the context for the Trial execution consisted of a massive release of liquid toxic substances as a result of maintenance failure in a reservoir which collects chemical wastes.

The solution selection process was the first step of the Trial 1. It was driven by the corresponding analysis of gaps, which was intended to reveal areas that can be improved in the existing practices, processes and daily operations related to Crisis Management in the context described by the previous Trial scenario. The solution selection process was aimed to select the most promising or best suited solutions (from those applying to participate in Trial 1) to bridge the gaps.

After the selection of solutions, the main steps in the process were the Dry Run 1 and Dry Run 2, during which the integration of solutions into the Test-bed and the general Trial set-up was assessed, and the Trial execution, in which these solutions were used in the context of an exercise with the participation of practitioners from different fields and countries.

Three solutions participated in Trial 1, Socrates OC, 3Di and Drone Rapid Mapping (DRM), being the two last ones provided by companies which were not a DRIVER+ partner (the so-called "external solutions"):

- Socrates OC is a web based tool for generating a Common Operational Picture (COP) in Crisis Management; it enables the exchange of information amongst nodes as well as doing tasking and resource management.
- 3Di is an interactive water simulation model which enables flood forecasting by constructing a COP of floods and exploring various future scenarios in a very short time frame (minutes).
- Drone Rapid Mapping solution enables fast generation of orthophoto maps based on imagery acquired by a Remotely Piloted Aircraft System which is available to Crisis Management actors.

These solutions were intended to achieve certain level of interoperability in order to have practitioners taking advantage of an integrated "System of Systems" which combined some of the benefits brought by each solution. The integration of solutions consisted of Socrates OC ingesting products generated by DRM and 3Di. Concretely, the latter ones provided georeferenced image files which were displayed as map layers in Socrates OC. From a technical perspective, this was found to be the soundest approach; from the operational perspective, it was expected to allow high-level decision makers to only focus on the Common Operational Picture provided by Socrates OC, including some of the 3Di and DRM's products (as map layers) combined with other operational information about events, missions and resources.

The means to achieve this interoperability was the DRIVER+ Test-bed. In this particular case, due to the fact that the Test-bed was being developed and it had no option to include a map server, and moreover the files provided by 3Di and DRM solutions were too big to be exchanged through it, it was decided that the Test-bed would not directly support the exchange of "operational" data between solutions, but instead would provide the means to distribute the notification messages about the availability of those data. This schema required putting in place additional components: a FTP server and a GeoServer. The overall process was as follows: the operator of the 3Di and DRM solutions provided a notification message (through the Test-bed) whenever one of their products was uploaded to the corresponding FTP server; this message was received by the operator of the GeoServer, who downloaded and processed them in order to be published to the GeoServer and be accessible as map layers; once they were uploaded, the GeoServer operator sent an additional notification message which was received by the Socrates OC solution; the operator of the Socrates OC solution was then able to connect to the GeoServer (using a Socrates OC feature) and import the corresponding map layers into the Socrates OC's Common Operational Picture.

The Test-bed had a second main role as the means to enable the reception by the Socrates OC solution of resources simulated by the XVR Resource Management (XVR-RM) simulation. XVR-RM was in charge of providing simulation support to Trial 1, by means of simulating and reporting a set of resources (e.g. units with certain response capabilities) to be used in the Trial scenario. XVR-RM reported the corresponding resources and provided their new positions as they moved; this information was received by the Socrates OC solution which displayed the resources on its map.

The solution integration set-up required no technical adaptions to 3Di and DRM (external) solutions. Their operators were just expected to use an application which connected to the Test-bed in order to send the corresponding notifications about the availability of their output products (georeferenced image files). Due to the tight schedule, the development of this application was taken over by the Test-bed team, so to reduce the workload of the external solution providers, who were new to the project.

Due to its central role in integrating data coming from different sources, Socrates OC solution needed however several adaptions to be implemented. The work also included the development of the corresponding Socrates OC's Test-bed adapter (which had to process the reception of the corresponding notifications and resource updates coming through the Test-bed and feed Socrates OC solution with them), the deployment of the FTP server and the GeoServer and the development of the notifications web application to be used by the operator of the GeoServer.

The Trial execution was split into several sessions, each of them focusing on a specific solution.

Socrates OC was used as the COP tool at the Command Centres simulated in Trial 1. At each centre, a specific instance of Socrates OC was deployed. Socrates OC was used in sessions 1, 2 and 4. During each session, a different operational configuration was established, in order to evaluate the performance and capabilities of the solution in different contexts.

3Di was used in its own Trial 1 Session to get an overview of the flood pattern of the chemical spill. One team of practitioners had 3Di available to decide on the evacuation order of selected buildings while the other team did not have 3Di available. The aim of the Trial was to test the operational use of 3Di during a Crisis Management situation, and whether 3Di could support the crisis managers in their decision making process on evacuation.

DRM was used in Trial 1 with two different purposes. The first one was to simulate an attempt to remotely measure the breach in a levee of reservoir containing a dangerous substance, without risking rescuers exposure. The second one aimed at attempting to locate any people that needs to be evacuated from the flooded area (people to be evacuated was "simulated" by sheets put in random locations). Both missions were performed by flying over the terrain of testing grounds in Kazuń Nowy.

The overall impression of the solution providers about Trial 1 was good. They found it as a good opportunity to give visibility to their solutions, cooperate with other solution providers in the Crisis Management domain and gather valuable feedback from practitioners and experts in different fields. There are anyhow a series of lessons learned which focus on the aspects to be improved from the solution providers perspective. Most of them revolve around the tight schedule of Trial 1, the demanding requirements taking into account that schedule, the late requests for changes and the lack of enough information at the first stages of the Trial process, such as the Call for Applications and the initial acceptance of solutions (when the Trial scenario, the data collection plan, etc., had not been defined yet, again mostly due to the tight schedule of Trial 1). Some consequences of these negative aspects were for instance: not achieving the formal commitment by external solution providers until one week before the Dry Run 1, difficulties by solution providers in gaining the knowledge to prepare the integration in the required timeline and the technical integration with the Test-bed not being achieved during Dry Run 1.

Table of Content

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
AIS	Automatic Identification System
AVL	Automatic Vehicle Location
C2	Command and Control
C3	Command, Control and Coordination
CM	Crisis Management
CMC	Crisis Management Centre
CIS	Common Information Space
COP	Common Operational Picture
CTR	Controlled Traffic Region
DB	Database
DEM	Digital Elevation Model
DoW	Description of Work
DR1	Dry Run 1
DR2	Dry Run 2
EC	European Commission
EMSI	Emergency Management Shared Information
FTP	File Transfer Protocol
GIS	Geographic Information System
IATA	International Air Transport Association
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LTE	Long Term Evolution
OC	Operations Centre
OSOCC	On-Site Operations Commanding Centre
PC	Personal Computer
REST	REpresentational State Transfer
RPAS	Remotely Piloted Aircraft System
SITREP	SITuation REPort
TIFF	Tagged Image File Format
VLOS	Visual Line Of Sight
WFS	Web Feature Service
WMS	Web Map Service

1. Introduction

This document has been elaborated in the context of the **Task 942.2 *Applying solutions in the trials***, which is part of the work package **WP942 *Solutions in trials***.

The main objective of WP942 is to assure "*that relevant and appropriate solutions from WP934 are identified (including external solutions), prepared and deployed in the Trials context*" (1). Task 942.2 specifically focuses on assuring that selected solutions are ready to be used in Trials, which includes:

- Configuring the solution as required by the Trial Committee or practitioners for its usage in the Trial.
- Supporting the usage of solutions during the Trials, so end users can concentrate on running the Trial and assessing the outcomes.
- Support the Trial Owner in configuring and analysing the solution-specific aspects of the Trials (e.g. the integration of solutions into the DRIVER+ Test-bed, interaction between the different solutions, etc.)

The main inputs to this task are:

- The solutions which pass the solution selection process, some of which may come from **WP934 *DRIVER+ CM solutions*** (the so-called "internal solutions") while others from non-DRIVER+ partner companies (the "external solutions").
- The concrete requests from the Trial Owner (e.g. outcomes from Workshop "0" and Dry Runs), some of which may require adaptions to the selected solutions.

The main outputs are the corresponding selected solutions ready for being used in the corresponding Trial.

This deliverable is associated to Trial 1, whose Dry Runs and final execution were held in Warsaw, Poland, between the beginning of April and the end of May 2018.

Trial 1 was mainly expected to focus on cross-border tasking and resource management connected gaps. The Trial should demonstrate the potential interest of a more integrated high-level Crisis Management (CM) system in Europe, especially in cross-border contexts in terms of improved situation assessment, coordination, resource pooling & sharing, and cross border cooperation. The Trial itself should also serve as a demonstration of potential of a Common Operational Picture approach on a European level, and to mature the DRIVER+ methodology and Test-bed for the Trial preparation process.

This deliverable specifically addresses the activities carried out by the corresponding solution providers in order to have their respective solution ready to be used in Trial 1. This includes those activities which were performed in order to pass the corresponding Dry Runs (e.g. implementing and testing the required adaptions to the solution), and those devoted to prepare the solution for the execution of the Trial.

The document is structured as follows:

- Section 2 puts into context the activities related to the application of solutions during Trial 1. It provides a general overview of the Trial 1, including the Trial scenario, the associated gaps and research questions as well as its planning and schedule. It also introduces the application of solutions to the Trial: how they were expected to interoperate and to be integrated into the Test-bed.
- Sections 3, 4 and 5 focus respectively on the application of each of the solutions which were finally selected for participating in Trial 1 (Socrates OC, 3Di and Drone Rapid Mapping). For each solution, a brief introduction to it, an overview of the adaptions which were required for participating in Trial 1 and a description of its usage during the Trial is provided.
- Finally, section 6 provides some conclusions and lessons learned from the perspective of solutions (i.e., only considering the solutions dimension of the Trial).

2. General overview

This section provides a general overview on the design and planning of Trial 1 from a solutions perspective.

Section 2.1 summarizes the main objectives and structure of Trial 1, as it is reported in the corresponding Trial Action Plan (2).

Section 2.2 briefly describes Trial 1's planning activities and the schedule for them, with special attention on solutions.

Section 2.3 provides an overall description of how selected solutions were to be integrated for Trial 1.

2.1 Trial 1 overview: scenario, gaps and research questions

The main purpose of Trial 1 was to evaluate how solutions may contribute to improve CM processes, by partially or totally bridging the defined gaps, in contexts such as the one represented by the Trial scenario.

As a said goal, which is general to DRIVER+ and all its Trials, Trial 1 was expected to test and validate the present status of the DRIVER+ methodology and Test-bed, in order to identify its shortcomings and strengths. Results were expected to allow improving both of them and undertaking the necessary corrective measures. This seeks to mature the guidance methodology with the aim to aid preparation, realization and evaluation phases of next Trials.

The specific objectives of the Trial can be summarized as follows:

- To simulate coordinated actions at the local, regional, national and international level with the purpose to counteract disaster effects.
- To test selected solutions for applicability.
- To evaluate the Test-bed.
- To validate the DRIVER+ methodology.

The scenario which provided the context for the Trial execution consisted of a massive release of liquid toxic substances as a result of maintenance failure in a reservoir which collects chemical wastes:

> *"A valve failure causes that pumps pumping chemical waste liquid to the reservoir cannot be switched off. Due to this, there is a rapid inflow of a significant amount of a liquid, mud like toxic chemical to the retention reservoir. Dikes of the reservoir are weakened after prolonged rainfall during past few days and under the influence of pressure the dikes break.*
>
> *The broken control station prevents a quick intervention and the increased pressure causing approximately 700 000 cubic meters of toxic, mud like, fluid as a massive 1-2 meter high wave that floods nearby localities in a matter of minutes. In the path of the spill are several villages and towns, where initially 15 people died and 200 people suffer severe toxic injuries. The eventual 30 square kilometres of affected land includes a river that crosses the border with a neighbouring country. There is a high risk of contamination for the river water. The river is a source of water intake for various industries, agriculture and fresh water companies. Consequential impact could result in destroyed crops, toxic injuries to livestock and a disturbance in the water supply causing immediate water shortage. The incident requires deployment of different kind of crises management and civil protection assets which are able to realize such functions as medical rescue, search and rescue, evacuation, decontamination, water purification, flood containment, temporary sheltering, etc."*

The scenario was based on the disasters which took place in Romania in 2000 (Baia Mare cyanide spill) and in Hungary in 2010 (Ajka alumina sludge spill), and it was consulted with:

- The Emergency Response Coordination Centre (ERCC).
- Representatives from the Joint Environment Unit (JEU UNEP/OCHA).
- The Organization for Prohibition of Chemical Weapon (OPCW).

- Former experts and colleagues who took part in the response for Ajka alumina sludge spill as the European Union Civil Protection Team (EUCPT).
- National Hungarian experts.

Figure 2.1 shows the set-up for the Trial, including the location of the chemical wastes reservoir and the border between two neighbouring countries Landpol and Manyger[1]. The concept for the Trial was to simulate the work of two Crisis Management Centres (CMC Landpol and CMC Manyger) on both sides of the border and the On-Site Operations Commanding Centre (OSOCC) based in the training field. The Trial was structured as a full-scale exercise divided into several "episodes" or "sessions" each of them focused on a particular aspect of the crisis response.

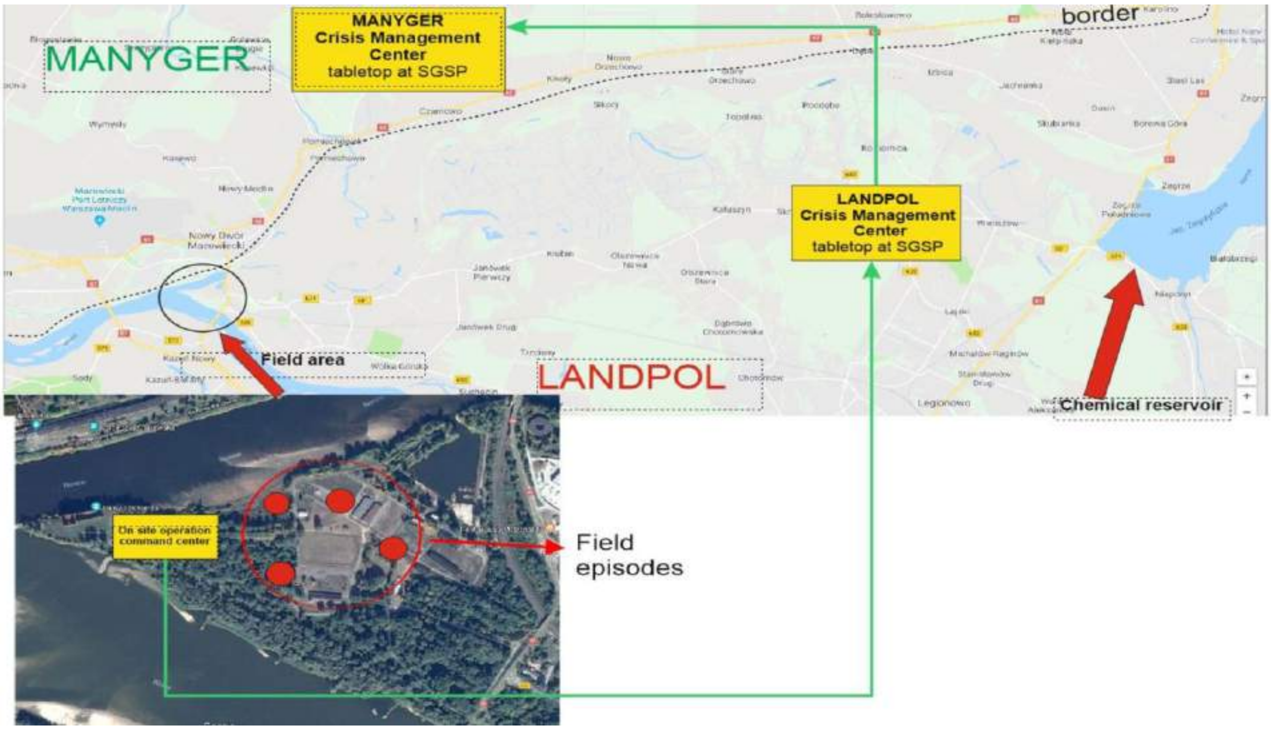

Figure 2.1: The Trial conceptual set-up

According to DRIVER+ methodology, the corresponding gap analysis was carried out for Trial 1. This analysis was intended to reveal areas that can be improved in the existing practices, processes and daily operations related to Crisis Management in the context described by the Trial scenario.

The gap analysis was conducted by the Trial Owner (SGSP) with the collaboration of their practitioners' network. The resulting list of gaps was presented during the DRIVER+ Gap Assessment Workshop where multiple stakeholders and practitioners (over thirty parties) were invited to discuss and assess the relevance of the presented gaps for them. After the received feedback, it was decided to focus on the following gaps[2] and their associated research questions:

- **Gap T1.1**: Limitations in the ability to model real-time (response phase) or pre-event (preparedness phase) dynamics of the chemical and radiological threat and visualisation of obtained results in a form that can be used directly by the Head of the Rescue Operations.
  Research questions:
  - How can visualisation of the chemical threat dynamics support communication and information exchange?

[1] Landpol and Manyger are fictitious countries which were put in place to simulate cross-border cooperation in a crisis event with an international impact.

[2] For a further description of gaps, the current state of the play and the required enhancements to "bridge" the gaps, refer to (2).

- **Gap T1.2**: Lack of a Common Operational Picture (COP) environment to integrate data sources and calculation results from different models crucial for decision making process from the perspective of Head of Rescue Operation.
  Research questions:
  - How can an integrated COP support decision-making processes at tactical and operational level?
  - How can models of chemical threat dynamics support taking decisions sooner, faster and better?
- **Gap T1.3**: Limitations in the cross vulnerabilities (people, property, environment) assessment to optimize task prioritization and decision making.
  Research questions:
  - How can models of cascading effects support taking decisions that minimise the impact on people, infrastructure and environment?
- **Gap T1.4:** Insufficiencies in terms of resource management (human resources, hardware, etc.) during multi-stakeholder long-term rescue operations.
  Research questions:
  - How can cross-border resource management be supported through socio-technical solutions during multi-stakeholder long-term rescue operations?
  - How can information on needed and available resources of multiple stakeholders be shared to increase the operational performance?
- **Gap T1.5**: Lack of effective public warning system with the ability to verify whether the information reached the recipient.
  Research questions:
  - How can verified communication to the public be coordinated between countries?

Previous gaps and research questions drove the solution selection process, which aimed to select the solutions more promising or better suited to address the gaps from those applying to participate in Trial 1.

2.2 Trial 1 planning and schedule

The planning of Trial 1 was divided into the following steps:

- **Solution selection:** The solutions which applied for participating in Trial 1 entered a review process which result was the main input for the selection of solutions by the Trial Committee.

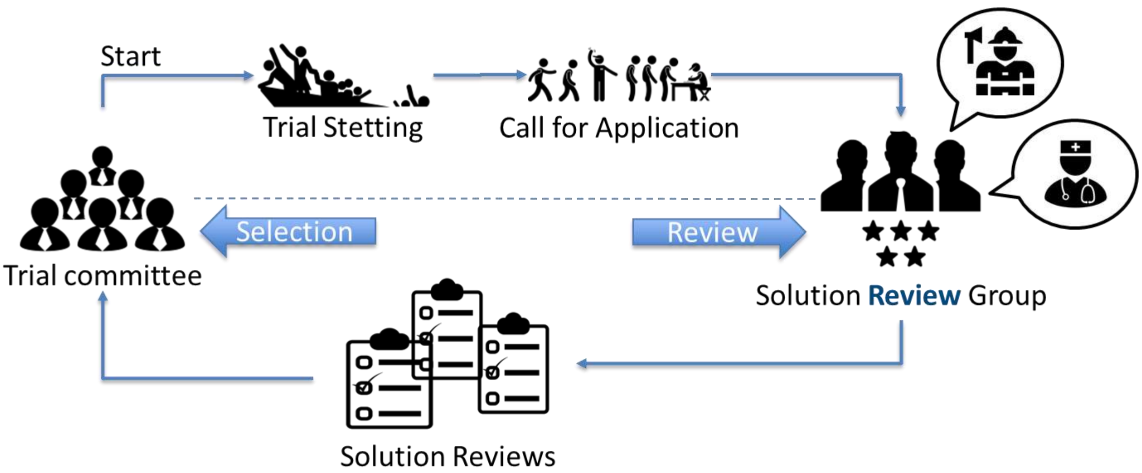

Figure 2.2: Solution selection process

This selection process was divided into a pre-selection made before Workshop "0" and an initial acceptance during **Workshop "0"**, where pre-selected solutions were presented to the Trial Committee by the solution providers. The main criteria for selecting solutions were their coverage of the gaps identified for Trial 1 and their adequacy to the related research questions (see section 2.1).

- **Dry Run 1**: Dry Run 1 (DR1) was mainly devoted to the technical integration of solutions and scenario validation. From a solutions perspective, its main objective was to allow checking the possibility of using solutions integrated into the DRIVER+ Test-bed[3] in the context of Trial 1, including: technical integration with Test-bed, solution maturity check and analysis of organisational and technical constraints, and training the Trial Committee in the use of the solutions.
- **Dry Run 2:** Dry Run 2 (DR2) was focused on training sessions in similar conditions to those expected for Trial 1 execution. The overall objectives, from a solutions perspective, were:
  - Final integration into the Test-bed.
  - Solution maturity check and analysis of organisational and technical constraints.
  - Theoretical and practical training on the use of the solutions for Trial 1 participants (mainly end users and practitioners).
  - Running a pilot Trial 1 with the practitioners' contribution.

  Starting at the initial acceptance of solutions and until Dry Run 2, solutions were expected to go through a process of adaption, integration and evaluation according to the Trial 1 needs (e.g., properly fitting the Trial scenario, satisfying operational requirements from Trial Committee, etc.). Dry Run 2 was intended as the final check of readiness for Trial 1.

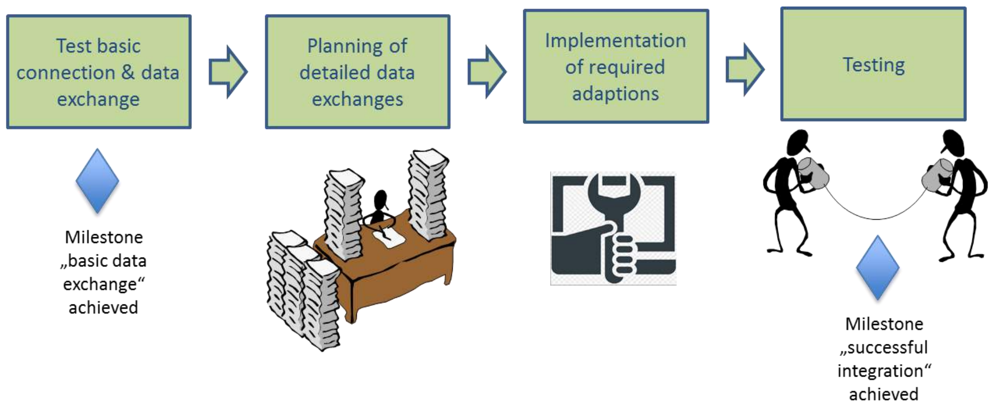

Figure 2.3: Solution integration process

- **Trial 1 execution:** Trial 1 consisted of a series of sessions, each of them focusing on a specific solution (or on a specific configuration of the solution), in which the Trial scenario was played and the solutions were used in a simulated operational context.

Table 2.1: Trial 1 schedule

Step	Purpose	Dates and location
Workshop "0"	Presentation and demonstration of solutions to Trial Committee.	**26/02/2018** to **27/02/2018** in Jozefow, Poland.
Dry Run 1	Technical rehearsal for solutions.	**04/04/2018** to **06/04/2018** in Warsaw, Poland.

[3] The DRIVER+ Test-bed is a pan-European arena of virtually connected facilities and crisis labs for Crisis Management capability development. It is aimed at enabling practitioners to create a space in which stakeholders can collaborate in testing and evaluating new products, tools, processes or organisational solutions. For further details about its technical infrastructure implementation, refer to https://driver-eu.gitbook.io/test-bed-specification (for functional specifications) and https://driver-eu.gitbook.io/test-bed-design (for the technical design).

Step	Purpose	Dates and location
Dry Run 2	Training and final rehearsal.	**24/04/2018** to **27/04/2018** in Warsaw, Poland.
Trial 1 execution	Usage of solutions in a simulated operational environment.	**21/05/2018** to **25/05/2018** in Warsaw, Poland.

2.3 Application of solutions to Trial1

After reviewing the applications, the Solution Review Group pre-selected 13 solutions to be presented to the Trial 1 Committee during Workshop "0":

- **3Di**: Interactive water simulation model which enables flood forecasting (flooding locations, water depths, water arrival times, etc.) by constructing a Common Operational Picture (COP) of floods and exploring various future scenarios in a very short time frame (minutes).
- **PROTECT**: Web based tool for notification, asking for and offering assistance (assets) in Crisis Management, with a repository of documents to support lessons learnt.
- **Team on Mission**: a high-end solution for instant messaging, voice, data, video, interoperability and location services in a secure environment.
- **APM-40:** Solution which allows restoring voice communication in the event of infrastructure destruction during a crisis situation.
- **Socrates OC**: web based tool for generating a Common Operational Picture in Crisis Management, providing functions for enabling the exchange of information amongst CM nodes and the reporting and tracking of events, missions and resources.
- **My MDA**: smartphone application allowing sending information about an event to the Emergency Medical Dispatch Centre equipped with a Command and Control (C2) system.
- **MDA Crew**: web-based application enabling first responders to exchange (mainly medical) information with the corresponding Operational Centres.
- **Drone Rapid Mapping**: Enables fast generation of orthophoto maps based on imagery acquired by a Remotely Piloted Aircraft System (RPAS) or drone which is available to rescue or crisis management actors.
- **LifeX COP:** Contributes to Crisis Management by collecting crisis relevant data from various sources and presenting them on a map interface. The COP offers various options to filter and search for data and display the result on the map or in list format.
- **DWR Debris:** Enables the user to gain support on the management of the debris and waste resulting from a crisis. It is an online application that integrates with satellite imagery and ground surveys to provide debris and waste data for a crisis affected area.
- **CRISE**: The solution contributes to create, set up and manage table-top simulation exercises, providing an in-depth, real-time and after-action review analysis of the decision-making processes during the exercise.
- **NowForce**: Computer aided dispatch system for incident management, which offers personal safety apps, cloud-based computer-aided-dispatch (CAD) and mobile response tools aimed at reducing response times, enabling full situational awareness and enhancing communications.
- **PLANET**: Collaborative mission management tool which enables sharing strategic and tactical management information in real time and a structured way, between crisis management stakeholders, anywhere in the world and in any situation.

From these, four solutions passed the initial acceptance by Trial Committee in Workshop "0", namely: 3Di, Socrates OC, Drone Rapid Mapping and NowForce. After the corresponding solutions providers were notified and invited for participation, NowForce solution provider withdrew from further participation[4].

The other three solutions got selected for Trial 1 after the initial acceptance and the subsequent negotiation phase, being two of them, 3Di and DRM, provided by non-DRIVER+ partner companies ("external solutions"). A more detailed description of these three solutions is provided here below:

- **Socrates OC** (GMV): Enhances analysis and decision-making capabilities by means of an improved and shared situational awareness based on relevant information about the operational situation including crisis events, missions and resources, created by the operator or coming from external sources. The information is displayed on a Common Operational Picture (COP). Socrates OC enables the exchange of the information among Socrates nodes enabling the reporting and tracking of events and inter-organisational tasking (mission assignment) and resource management (request and transfer of resources).
- **3Di** (Nelen and Schuurmans): Interactive water simulation model consisting of three core innovative aspects: 1) short computation times in combination with a high spatial resolution and an accurate prediction of floods, 2) ease of model adaptability to test suggested measures and 3) a realistic visualization of model outputs. This interactive model enables flood forecasting (prediction of flooding locations, water depths, and water arrival times, among others) by constructing a Common Operational Picture of floods and exploring various future scenarios. Scenarios can be explored and measures can be tested in a very short time frame (minutes).
- **Drone Rapid Mapping** (Dzial Hexagon Safety & Infrastructure): Drone Rapid Mapping (DRM) enables fast generation of orthophoto maps based on imagery acquired by a RPAS or drone which is available to rescue or crisis management actors. The resulting maps can be viewed and analysed in the dedicated geoportal or any GIS environment already utilized by crisis management institutions. The additional product is a 3D model of the terrain, enabling better and more intuitive understanding of the area of interest. Rapid generation of maps is enabled by cloud computing.

Further information on solutions and how they were used in Trial 1 are provided in sections 3, 4 and 5.

2.3.1 Interoperability of solutions

Trial 1 solutions were intended to achieve certain levels of interoperability in order to have practitioners taking advantage of an integrated "System of Systems" which combined some of the benefits brought by each solution. The implemented concept of interoperability of solutions is depicted in the following figure:

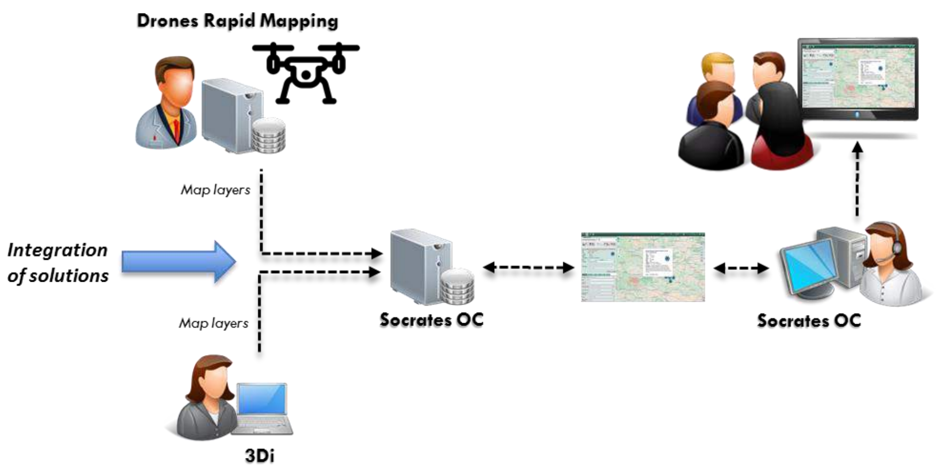

Figure 2.4: Concept of solutions interaction

[4] It has to be noted that, as the solution provider was not a partner of the DRIVER+ consortium, it was not obliged to communicate the concrete reasons to the Trial Committee.

Basically, this approach consisted of the Socrates OC solution ingesting products generated by Drone Rapid Mapping and 3Di (GeoTIFF[5] files to be displayed as map layers in Socrates OC). From a technical perspective, this was the soundest approach for integrating solutions. From the operational perspective, it would allow the specialized staff in the Crisis Management Centres to take advantage of the whole feature set of 3Di and DRM solutions while higher-level decision makers would only need to focus on the common picture provided by Socrates OC, which would display some of 3Di and DRM's products as map layers combined with other operational information about events, missions and resources.

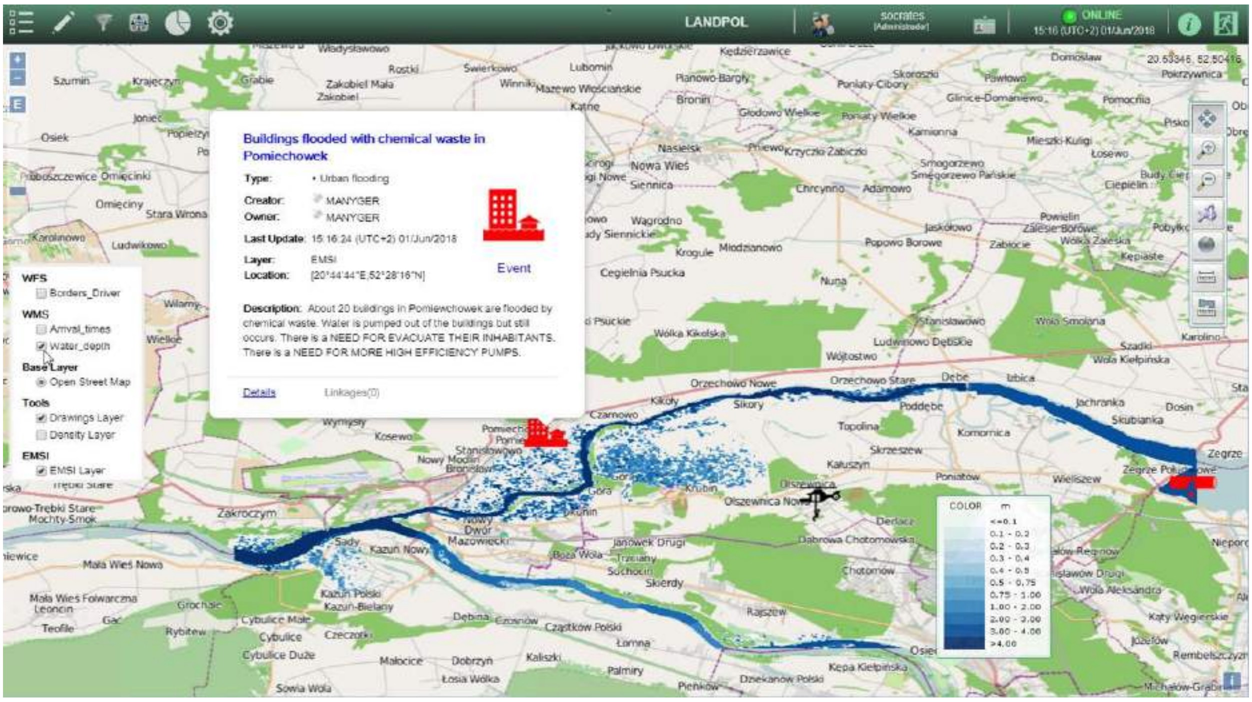

Figure 2.5: 3Di's water depth layer being displayed in Socrates OC

In order to achieve this level of interoperability, it was required that:

- 3Di and DRM made available their outputs to be gathered as map layers using WMS[6]/WFS[7] services.
- 3Di and DRM informed Socrates OC about the availability of the new map layers.
- Socrates OC properly gathered and displayed the corresponding map layers.

3Di and DRM already produced GeoTIFF files which are easily publishable as map layers to be later retrieved using WMS and WFS services. Moreover, Socrates OC already incorporated a feature for importing map layers through those services. This way, the aspects of interoperability which would have required the greatest efforts were already covered, and thus the implementation of the presented approach was feasible in the given timeframe.

The design for solutions integration was mostly sketched during the period between the Workshop "0" and Dry Run 1; how this integration was to be implemented by means of the Test-bed was discussed and defined during Dry Run 1. This already introduced a delay in the integration process according to how this

[5] *GeoTIFF* is a metadata standard which allows geo-referencing information, including map projection, coordinate systems, etc., to be embedded within a *TIFF* (*Tagged Image File Format*) file (https://trac.osgeo.org/geotiff/).

[6] WMS stands for *Web Map Service*. It is a standard protocol by the *Open Geospatial Consortium* for serving georeferenced map images (http://www.opengeospatial.org/standards/wms).

[7] WFS stands for *Web Feature Service*. It is a standard by the *Open Geospatial Consortium* for providing an interface allowing web requests for geographical features. Geographical features can be seen as the "source code" behind a map (http://www.opengeospatial.org/standards/wfs).

process was defined in the Trial methodology, in which Dry Run 1 was actually aimed to be a first technical rehearsal for the evaluation of the maturity and performance of the already integrated solutions. However, the short time between the final selection of solutions and Dry Run 1 made the original planning hard to follow, further considering the required phase of negotiation between the DRIVER+ consortium and external solutions providers.

The next section goes into further details regarding the integration of solutions into the Test-bed.

2.3.2 Integration of solutions into the Test-bed

The Test-bed was intended as the means to integrate solutions involved in the Trial, being its main task to support the technical implementation of the three requirements listed in previous section. Two main issues arose during Dry Run 1 and had to be taken into consideration:

- The Test-bed was being developed and it had no option to implement a map server providing WMS and/or WFS services at that point in time.
- The GeoTIFF files provided by 3Di and DRM were too big to be exchanged through the Test-bed.

Due to this, the Test-bed was not going to directly support the exchange of "operational" data between solutions but was providing the means to distribute the corresponding notification messages needed for the interaction of solutions. This schema required putting in place two additional components in order to enable the sharing of map layers: a FTP server where GeoTIFFs generated by Drone Rapid Mapping and 3Di solutions would be uploaded and a GeoServer where those GeoTIFFs would be published as shapefiles after the corresponding data processing.
The resulting architecture is shown in Figure 2.6.

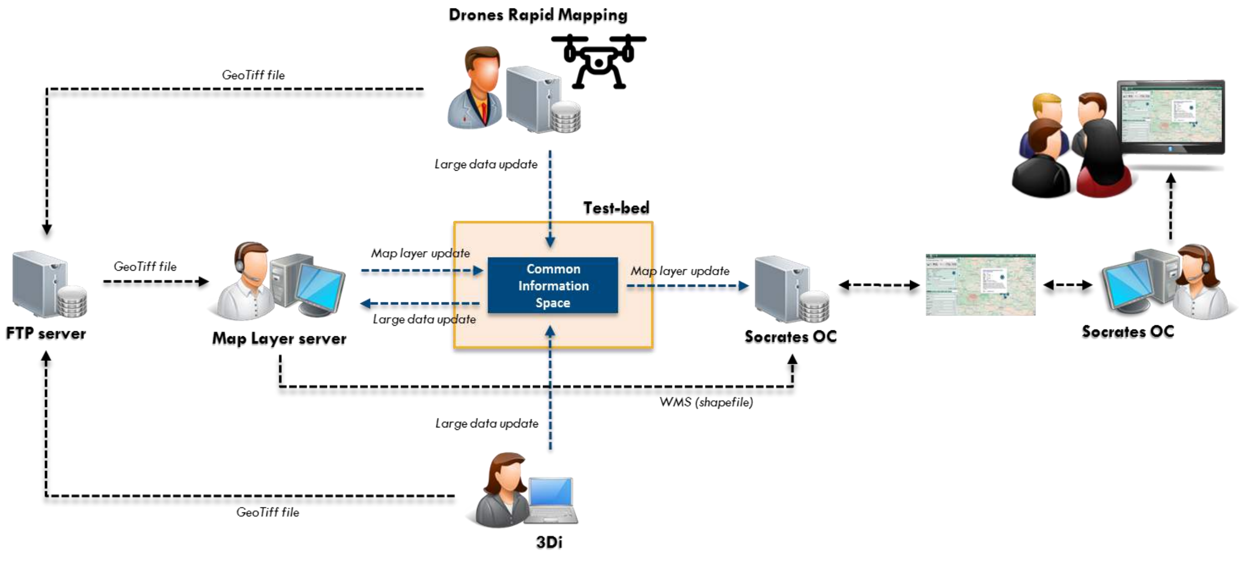

Figure 2.6: Solutions integration into the Test-bed

The three solutions (Drone Rapid Mapping, 3Di and Socrates OC) were connected to the Test-bed to provide/receive the corresponding notifications when new/updated data were available; i.e.:

1. Drone Rapid Mapping and 3Di would inform, by means of the large data update message, about the availability of new GeoTIFFs after uploading them to the FTP server.
2. The Map Layer Server would receive that message and, after downloading the corresponding GeoTIFF file, processing it and publishing the resulting shapefile in the GeoServer, a **map layer update** message would be delivered to communicate the availability of the new layer.
3. Socrates OC would receive the **map layer update** and display the associated map layer in the COP, by accessing the GeoServer through WMS.

The detailed sequence of interaction is illustrated by Figure 2.7. The format and contents of the large data update and the map layer update messages were defined by the Test-bed team and incorporated to the Test-bed's infrastructure as ad-hoc standards for notifications. This way, the Test-bed was in charge of distributing received messages to those recipients which were subscribed to the corresponding Kafka topics[8].

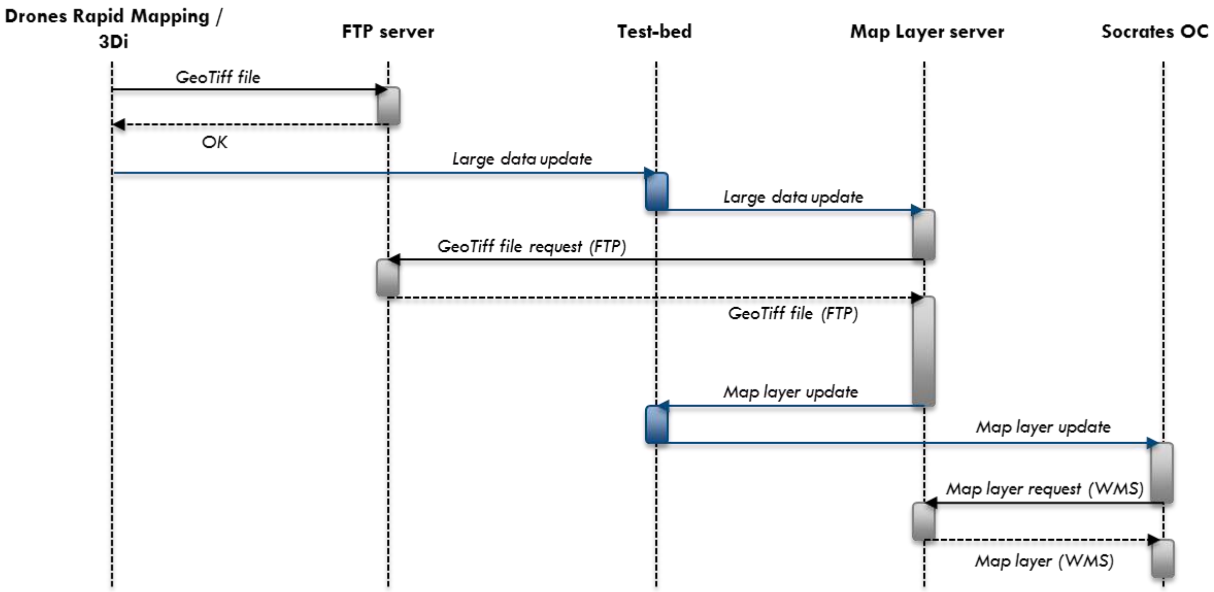

Figure 2.7: Solutions interaction

Each solution was responsible for properly managing the part of the interaction it was involved in, which included the selection and customization of one of the available Test-bed adapters as well as the development of any additional required functionality (either in the corresponding adapter or the solution itself). In the case of external solutions and due to the tight schedule, this task was facilitated by the Test-bed team (TNO, FRQ), who developed the corresponding notification web applications so to allow the operators of Drone Rapid Mapping and 3Di solutions to send large data update messages. Apart from developing the corresponding Test-bed adapter for Socrates OC solution (for receiving map layer update messages), GMV took responsibility for deploying the Map Layer server and developing the required functionality associated to it. This Map Layer server consisted of:

- An additional notifications web application which allowed its operator to receive large data update and send map layer update messages.
- A georeferencing solution that enabled the processing of the corresponding GeoTIFFs as required (see section 3.1.2).
- A GeoServer where the map layers based on those GeoTIFFs were published.

Additionally, there was a second kind of integration into the Test-bed consisting of the reception by Socrates OC solution of resources simulated by the XVR Resource Management (XVR-RM) simulation. XVR-RM was in charge of providing simulation support to Trial 1, by means of reporting the set of resources (e.g. vehicles or units with certain response capabilities) being managed during the Trial and providing the corresponding position updates as they moved. The process was as follows:

- XVR Resource Management sent simulation entity item messages, including basic information about resources (name, type and position), to the Test-bed's Common Simulation Space.
- These messages were captured by the XVR entity to GeoJSON Gateway (developed by TNO) which injected them into the Common Information Space (CIS) as GeoJSON-formatted messages. This

[8] Apache Kafka is the underlying technology for the DRIVER+'s Test-bed message exchange. It is designed according to the publish/subscribe pattern; a "topic" will define a type of message which clients can subscribe to. Further info can be found in https://kafka.apache.org/.

way, resources information was accessible by "operational" solutions, which only had access to the CIS.

- Finally, the information within previous GeoJSON messages was received by Socrates OC.

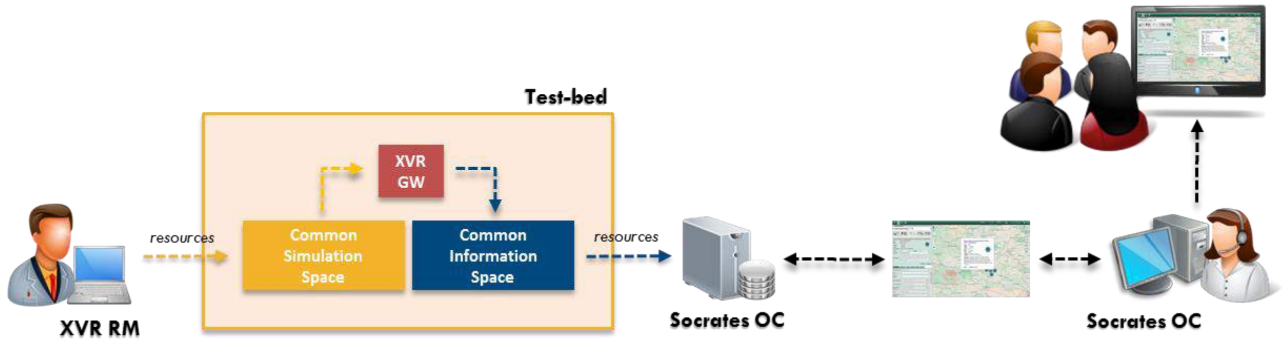

Figure 2.8: XVR RM-Socrates OC interaction through the Test-bed

Figure 2.8 shows the resulting architecture for the XVRRM-Socrates OC interaction through the Test-bed. The intended result of this integration was having resources simulated by XVR RM displayed in the COP provided by the Socrates OC solution, as illustrated in Figure 2.9.

Figure 2.9: XVR simulated results in Socrates OC's COP

3. Application of Socrates OC in Trial 1

As introduced in section 2.3, Socrates OC solution supports Command, Control and Coordination (C3) and decision-making processes by providing COP-based sharing of situational awareness and functionalities for tasking and resource management in crisis scenarios. One of its key features is that it enables setting up a network of nodes each one deployed in the corresponding Operations Centre which allows the exchange of information about the operational situation which can be geolocated in a GIS-supported COP.

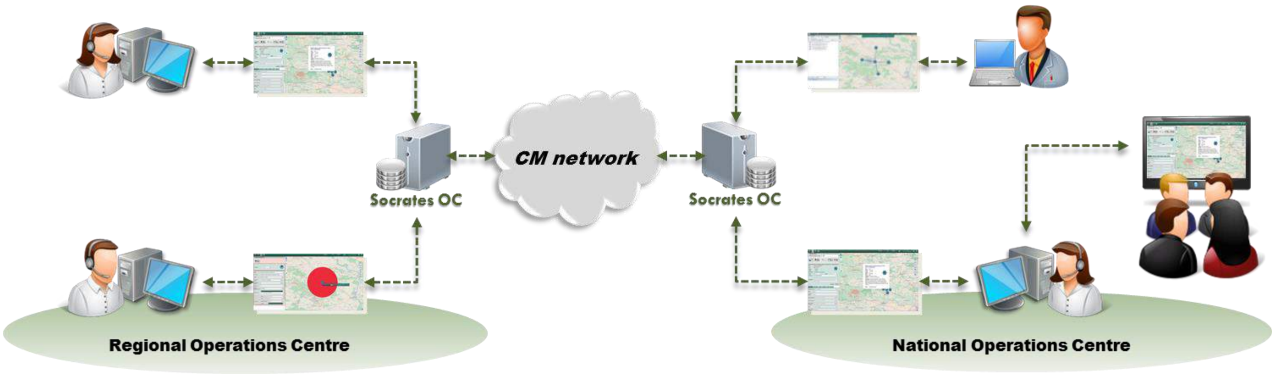

Figure 3.1: Example of a Socrates CM network

The sharing of information through the Crisis Management (CM) network (as depicted in Figure 3.1) relies on a basic business rule whose main aim is to maintain the consistency and reliability of the exchanged data: only the owner of a Socrates entity/object (an event, mission or resource in DRIVER+) can delete it or update its related information. The default owner of an object is the node which created it. In order to deal with special situations such as requests of resources or the transfer of their control between organisations, specific mechanisms are available (e.g. transferring the ownership of an object between nodes).

It has to be noted that partial updates are not allowed by Socrates OC; when a given entity is partly updated by its owning node (e.g. the value of some attribute is changed), the whole entity will be transmitted to the other nodes.

As outlined in previous, section, the integration of Socrates OC solution into the Test-bed responded to two main purposes:

1. Receiving simulated resources from the Test-bed and displaying them in Socrates OC solution.
2. Receiving map layer update notifications so to inform the Socrates OC operator about the availability of a new map layer which can be retrieved and displayed in the solution.

From these two general requirements, a series of activities and required functionalities were derived. The following two sections briefly describe the main activities and the required functionalities derived from these two general objectives, some of which have been already introduced in section 2.3.2.

3.1 Required adaptions

3.1.1 Adaptions for reception of simulated resources

The reception of simulated resources from the Test-bed had several implications. The first and obvious one was the need for developing a dedicated Test-bed adapter (which was built on the generic Java Test-bed adapter[9] developed by FRQ) to listen to XVR GeoJSON messages (GeoJSON-formatted messages including the information of resources being simulated by XVR) distributed by the Test-bed, process them and

[9] The *Java Test-bed adapter* is an application that facilitates *technological solutions* written in Java to connect to the Test-bed and send and receive messages through it. For technical details, refer to https://github.com/DRIVER-EU/java-test-bed-adapter.

provide Socrates OC with the corresponding resource updates. These resource updates might consist of an actual update or the creation of a new resource if it is reported for the first time.

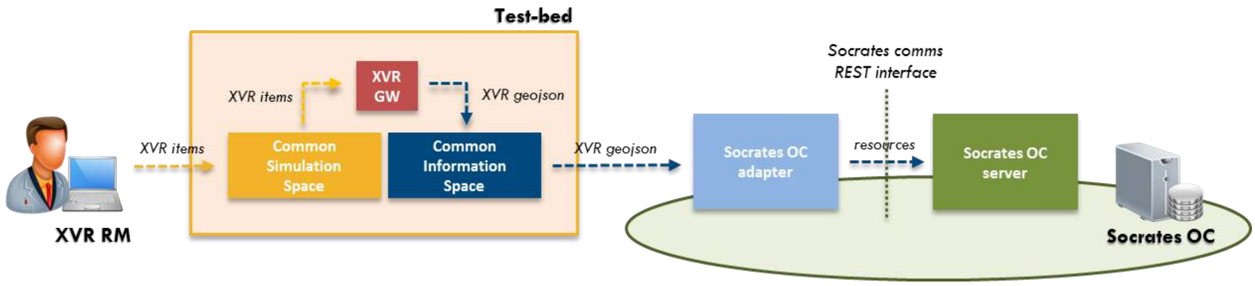

Figure 3.2: Components involved in the reception of resource updates by Socrates OC

In order to avoid ad-hoc modifications to the Socrates OC solution for its integration with the DRIVER+ Test-bed and keep solution's autonomy, the Socrates adapter was designed to act as an emulator of another Socrates OC instance (node) which was providing information about its resources. In this case, however, resources could be updated by two different nodes, the adapter which received position updates from the simulation and the corresponding Socrates OC instance[10], in which the operator could add any other information associated to the resource.

In order to avoid the overwriting of resources' data, it was required to adapt Socrates OC to support partial updates (which were not originally supported, as mentioned above) and to receive updates from a node which was not the resource's owning node (this was just a temporal adaption for Trial 1).

Additionally, during Trial 1's Dry Run 2 a performance issue was detected in Socrates OC when it had to deal with the reception of hundreds of resources at once (as required for the Trial set-up at that moment, which included hundreds of vehicles and locations). The performance issue had to do with the fact that the used Socrates OC version relies on an elaborated data model for its objects (events, missions and resources in DRIVER+), including versioning, support for dynamic attributes, cross-references, etc., which is not intended to handle high rate updates.

In operational contexts requiring high-rate updates (e.g., handling of AVL traces or AIS traces), different approaches have been followed (e.g., using a dedicated lighter data model for the affected objects or avoiding real-time DB storage). However, in the given Trial 1's timeframe it was not feasible to develop such a solution for this case; instead, additional business logic was added to the Socrates adapter in order to deal with the issue.

3.1.2 Adaptions for reception of map layer update notifications

Test-bed's map layer update notifications were intended to inform the Socrates OC operator when a new map layer was made available at some WMS/WFS-compliant server, so the layer could be retrieved and displayed by the solution. These map layers were based on the GeoTIFF output provided by 3Di and DRM solutions.

During DR1, it was agreed that the operator of these solutions would be in charge of uploading the corresponding GeoTIFF files (flood arrival times and flood water depth models, in the case of 3Di, and orthophoto maps of the area of interest, in the case of DRM) to a FTP server and send right after a large data update notification message through the Test-bed. This notification (which included the name and description of the file and the URL of the corresponding FTP server it had been uploaded to) had to be received by the operator of the Map Layer server, who would download the file from the FTP, process it

[10] Two main instances/nodes were used in Trial 1: one for the *CMC Landpol* and other for the *CMC Manyger*, representing the *Crisis Management Centres* for two different regions; the corresponding owning node for each resource was determined by the *Socrates adapter* according to the geolocation of the resource, after discarding the possibility of the owner node being directly provided by the simulation tool as part of the resource information.

accordingly and finally publish the resulting shapefile to a GeoServer instance included in the Map Layer server.

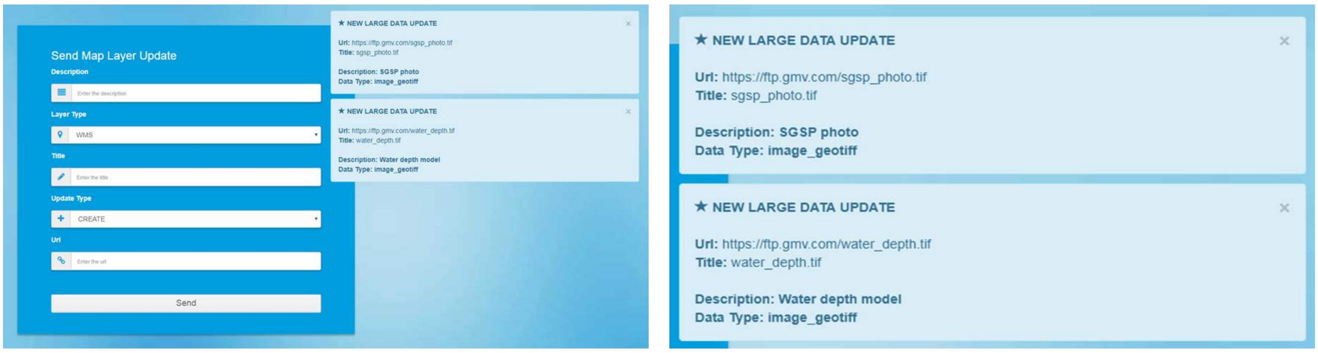

Figure 3.3: Reception of large data update messages by the Notifications web app

In order to handle notifications, a web application connected to the Test-bed (and also based on the Java Test-bed adapter) was developed to listen to the large data update notifications and generate the corresponding map layer update notifications once the map layers had been published (see Figure 3.3). The message exchange schema is depicted by Figure 3.4.

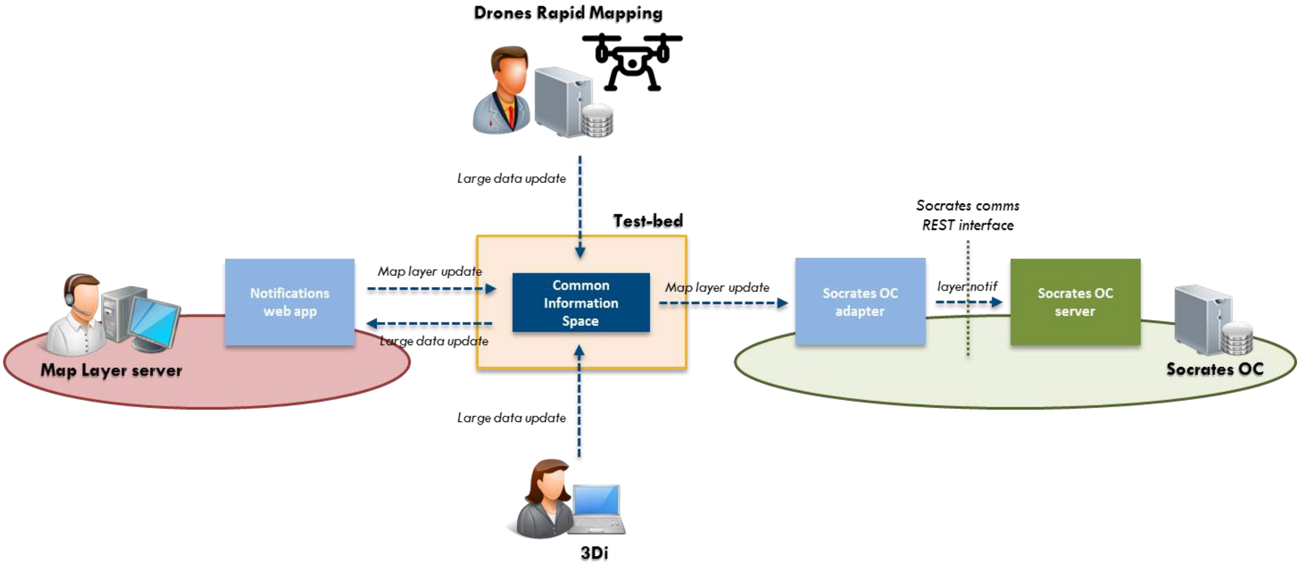

Figure 3.4: Components involved in the reception of map layer updates by Socrates OC

The processing of GeoTIFF files consisted of the following operations:

- In the case of orthophotos by DRM, just publishing them as a shapefile in the GeoServer.
- In the case of products by 3Di, it was required to change the original reference coordinates to the EPSG4326 system used by Socrates OC and colouring the uniband rasters of the original files, in order to improve their interpretability by the Socrates OC operator.

Once the map layer was published and the Map Layer server operator generated the corresponding map layer update message (including the name and description of the layer and the URL of the GeoServer), this message was captured by the Socrates adapter which notified Socrates OC (see Figure 3.5). The Socrates OC operator was then able to retrieve and display the map layer in Socrates OC according to the information provided within the notification (see Figure 3.6).

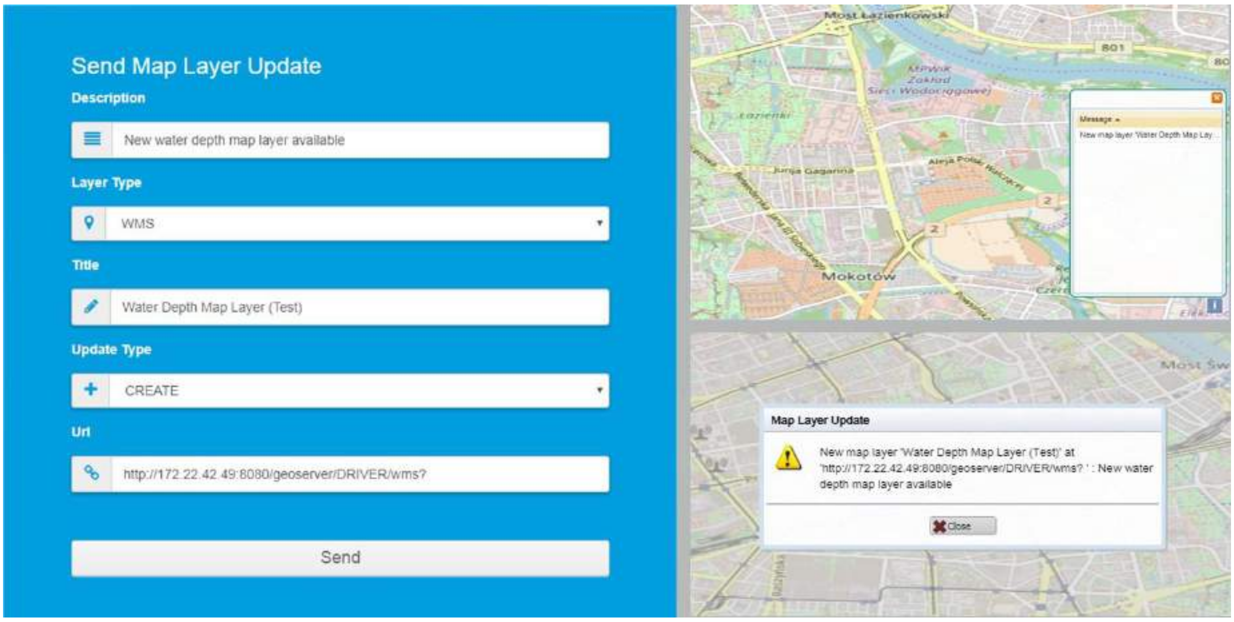

Figure 3.5: Sending (Notifications web app) and reception (Socrates OC) of map layer update messages

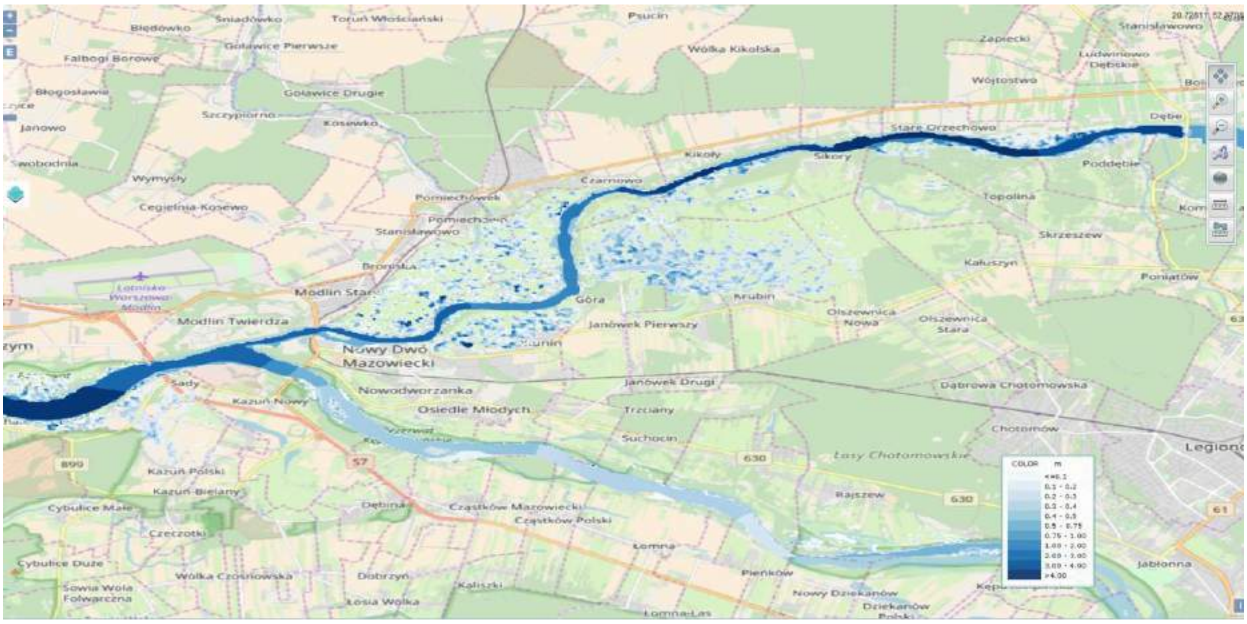

Figure 3.6: Example of water depth map layer displayed in Socrates OC

3.1.3 Adaptions requested by the Trial Owner

There was a third set of adaptions directly related to the functionality of Socrates OC solution which were requested by the Trial Owner.

The first one concerned the set of icons being displayed. Socrates OC is provided with a simple default set of icons and it is usually the end user organisation where the solution is being deployed which provides with its own symbology to be incorporated in the tool. Socrates OC is specifically designed to be easily customizable for using different icons for its predefined object types.

For Trial 1, however, it was defined a set of resource types which was not the one used by Socrates OC by default (Socrates OC's data model is compliant with EMSI[11] standard). The solution had to be first

[11] EMSI stands for *Emergency Management Shared Information*. It is an ISO *Technical Report* which specifies a message structure for the exchange of information related to Emergency Management (see (4)).

configured for using the types of resources defined in Trial 1. After it, the solution provider was in charge of searching for a proper set of icons for those resources types and incorporating them to the tool, as no specific symbology was provided by the Trial Owner. Something similar was also done for icons corresponding to mission and event types.

It has to be noted that the set of resource types was redefined according to practitioners' comments and expectations during DR2[12]. Till DR2, the types of resources were vehicles according to the types supported by XVR; after it, the concept of module was introduced, as specified by the European Commission (EC) decision on a Union Civil Protection Mechanism[13]. This required repeating the process of customization of the solution in the period between DR2 and the Trial 1 execution (two examples of event and resource types and their associated icons are shown in Figure 2.5 and Figure 2.9).

The second adaption requested by the Trial Owner was related to the way assignments were done. During Dry Run 1, resources were assigned to missions and events using the features provided by Socrates OC. However, during the Trial rehearsal done as part of DR2, it turned out that the solution did not provide a clear enough way to figure out that a given resource was already assigned to some event or mission. Indeed, the list of resources assigned to a given event/mission was displayed by the solution as part of the information related to that event/mission. However, the corresponding event/mission was not displayed as part of the information related to the corresponding resources. This was confusing for practitioners and at the end of DR2 the Trial Owner asked the solution provider to implement a way that allowed the operator of the solution to know immediately whether a resource had been already assigned to an event or a mission at the very moment the resource was selected in the COP.

The implemented adaption consisted of displaying two new fields in the resources' Details panel including the event and/or mission (if any) the resource was assigned to. This way, once a resource was selected in the COP, the operator could open its Details panel (see Figure 3.7), see whether the resource had an assigned event/mission and even click on the corresponding link to see the location and related information to that event/mission.

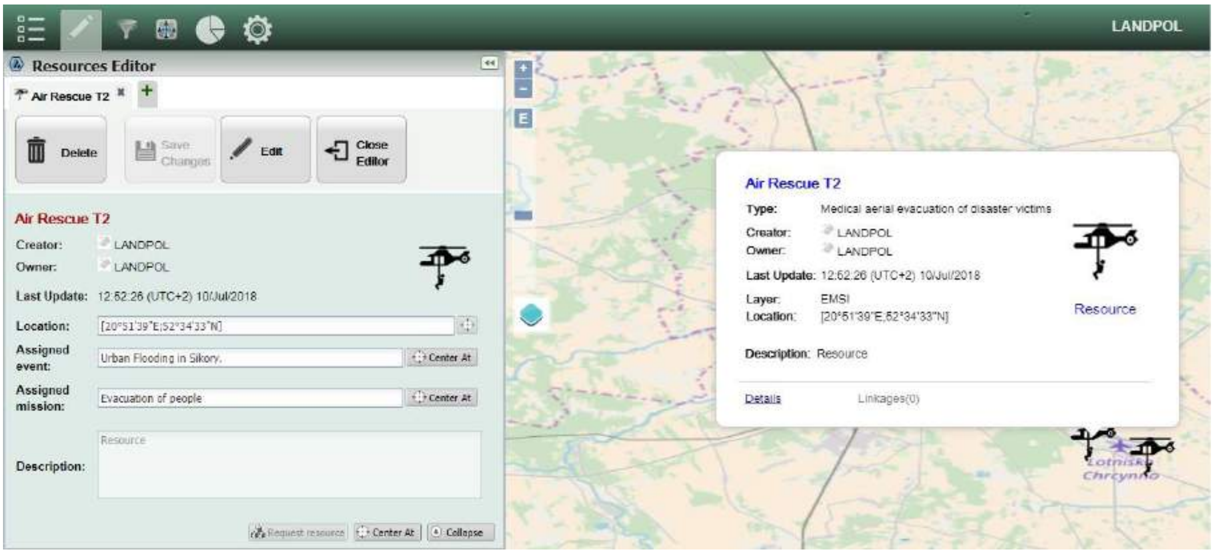

Figure 3.7: Assigned event and mission in the Resource's Details panel of Socrates OC

Finally, the Trial Owner proposed, as part of the activities to be carried out by practitioners during the execution of Trial 1, filling a situation report according to the Template for Daily Reports (for expert missions) of the Union Civil Protection Mechanism (see Annex 2). Thus, the Socrates OC solution provider was requested to support this activity by automatically generating a text document (.doc, .pdf) compiling the information about the situation included by Socrates OC at the moment of filling the corresponding

[12] As described in section 2.1, DR2 included a rehearsal session which involved some of the practitioners participating in Trial 1.

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.320.01.0001.01.ENG

report. This document should be aligned with the situation report template so contents of the former could be easily reusable to be included in the latter.

As a result, Socrates OC was equipped with a new Report Generation functionality which was ready for the execution of Trial 1.

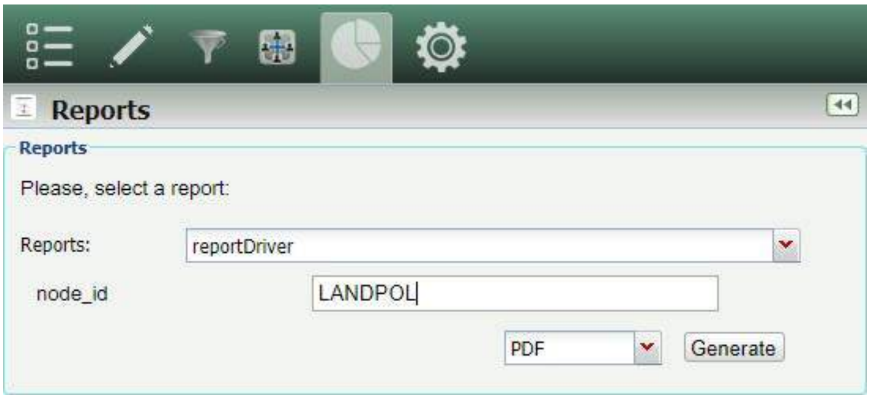

Figure 3.8: Socrates OC's Report Generation feature

3.1.4 Summary

As described in previous sections, the participation of Socrates OC in Trial 1 required a set of new functionalities spread amongst the Notifications web application, the Socrates adapter and the Socrates OC solution itself. These functionalities, as well as the dates in which they were requested or identified, are summarized in the following tables (the first one, for functionalities derived from the integration of the solution into the Test-bed; the second one for those related to adaptions requested by the Trial Owner):

Table 3.1: Required functionalities for the integration of Socrates OC solution into the Test-bed

Component	Required functionality	Since
Socrates OC	**SOC#01** Partial update of resources.	W"0"
	SOC#02 Reception of map layer update notifications.	W"0"
	SOC#03 Display of key legend for the interpretation of the colour codes associated to the flood arrival times and flood water depth map layers.	DR1
Socrates adapter	**SOC#04** Reception of XVR GeoJSON messages and gathering of the resource info inside them.	W"0"
	SOC#05 Creation of Socrates resource update messages based on the info inside XVR GeoJSON messages and transmission of them to the corresponding Socrates OC node.	W"0"
	SOC#06 Reception of map layer update messages and generation of the associated notification to the corresponding Socrates OC node.	W"0"
	SOC#07 Identification of the owner node of each resource based on the geographical location provided by the simulation.	DR2
	SOC#08 Management of the Test-bed messages update rate in order to avoid performance issues in Socrates OC.	DR2

Component	Required functionality	Since
Notifications web application	**SOC#09** Reception and display of large data update notifications.	DR1
	SOC#10 Transmission of map layer update notifications.	DR1

Table 3.2: Functionality requested by Trial Owner

Component	Required functionality	Since
Socrates OC	**SOC#11** Management of the types of resources to be used in Trial 1 and of a proper set of icons for them. **Note:** During DR1, it was decided to work with the vehicles supported by XVR. During DR2, it was decided to work with modules instead of vehicles.	DR1, DR2
	SOC#12 Easy identification of the event/mission a resource is assigned to.	DR2
	SOC#13 Generation of situation reports according to the format and contents to be used in Trial 1.	DR2

The set of tests run to validate previous functionalities as well as their corresponding results are documented in deliverable (3).

3.2 Solution usage in Trial 1

The solution was used as the COP tool at the Command Centres simulated in Trial 1. At each centre, a specific instance of Socrates OC was deployed (each centre corresponding to a Socrates node, as illustrated in Figure 3.10). Three Command Centres were in place: the CMC Landpol, the CMC Manyger and the OSOCC. As introduced in section 2.1, CMCs represented the Crisis Management Centres for two different regions, Landpol and Manyger (Figure 3.9 shows the borders of these regions, as they were displayed in the Socrates OC solution), in charge of responding to crisis events in the areas under their responsibility[14]. The OSOCC represented the On-Site Operations Commanding Centre deployed on field.

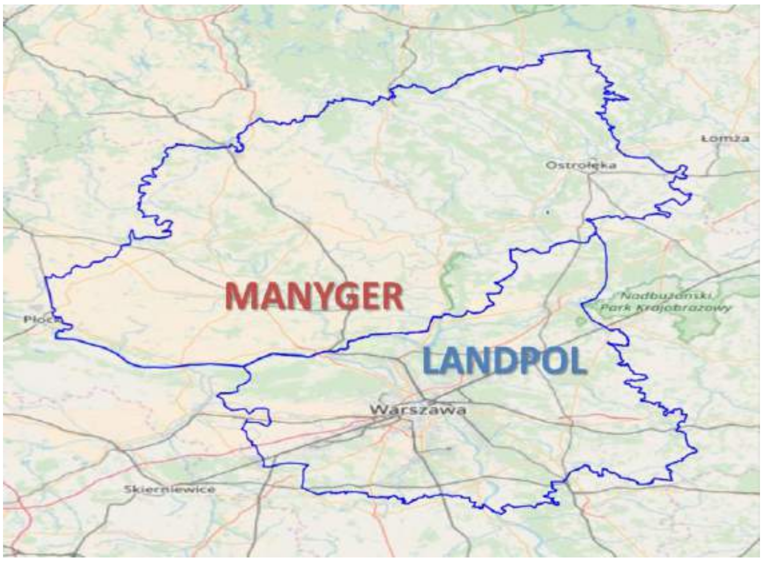

Figure 3.9: Landpol and Manyger borders displayed in Socrates OC

[14] The event originating the crisis scenario defined in Trial 1 was located in between these two regions.

The practitioners operating the solution were responsible for deciding how to assign the available resources to the different on-going events and missions displayed in the COP. These resources, events and missions could have been reported by phone or mail from the field or by other Socrates OC nodes, depending on the particular operational configuration.

Trial 1 execution was divided into five different sessions each one focusing on a particular solution. Sessions 1[15], 2 and 4 focused on Socrates OC. During each session, a different operational configuration was established, in order to evaluate the performance and capabilities of the solution in different contexts.

Figure 3.10: Socrates network set-up during Session 2

Figure 3.10 shows the set-up for Session 2, in which two Socrates nodes deployed in the CMCs were connected and sharing information (Figure 3.11 shows practitioners using Socrates OC in one of these nodes). Session 1's set-up was similar but without having a connection between nodes (two nodes can be easily connected/disconnected by changing the corresponding Socrates configuration files). These two configurations were expected to show the difference between an operational scenario in which each CMC acted on its own without any knowledge about the activities and the available resources in the other CMC (except from those communicated via phone or mail), and a scenario in which all the information was shared.

Session 4 ran in parallel with two different set-ups. In one of them the CMC Landpol and the OSOCC were connected to each other just as CMC Manyger and CMC Landpol were during Session 2 (Figure 3.10). The other set-up consisted of a Socrates OC deployed at the CMC Landpol connected with the OSOCC via phone. Again, these two scenarios were aimed to show the differences in performance in different contexts and compare to which extent the information about the operational situation being compiled at each location (i.e., at the OSOCC and the CMC Landpol) matched in the different scenarios.

Figure 3.11: Practitioners using Socrates OC during Trial 1

[15] A late modification required after Dry Run 2 (three weeks before the Trial execution) introduced an error in the Test-bed adapter of the Socrates OC solution which prevented it from receiving resources from the Test-bed after some minutes being used during the Trial execution. Due to this, Session 1 with Socrates OC solution had to be stopped and restarted later. In the meanwhile, the session corresponding to the 3Di solution was carried out.

4. Application of 3Di in Trial 1

The hydrodynamic model 3Di supports decision-making in crisis management situations. As described in paragraph 2.2, the 3Di instrument is accurate, fast and visible. With these abilities 3Di provides flood simulations that can instantly help to get a better Common Operational Picture and raise situational awareness among all stakeholders (including non-experts). Furthermore, 3Di provides the possibility to alter the model instantly to calculate other possible scenarios; for instance to see and measure the effects of possible measures.

Figure 4.1: User interface of the 3Di livesite.

In Trial 1 the 3Di instrument was tested as a solution to improve both the COP and the situational awareness in flood simulations. To test the added value in Trial 1 two teams had the assignment to make a priority list for the evacuation of designated buildings in the area, following a scenario of a toxic flood originating from a breach in a storage of toxic mud located at Zegrzynski lake. One team had the possibility to use the 3Di model. The other team received static information as their source of information. The team with 3Di had the possibility to use the model interactively for optimal insight into the flood pattern, arrival times and the effect of potential measures on the disaster. To execute a valid test of the added value of 3Di in the Driver+ program several preparations were carried out. Section 4.1 describes these steps. Section 4.2 describes how 3Di was used during the Trial.

4.1 Activities in the preparation of Trial 1

There were no technical adaptions required for the usage of the solution in Trial 1. However, there were a series of preparation activities needed to be done. Concretely, 3Di was prepared in three ways for Trial 1:

1. The technical integration of 3Di with the Test-bed and Socrates OC.
2. Building a 3Di model for the selected area of interest.
3. Configure the 3Di model to be ready-to-use during the Trial.

In the next paragraphs each of the preparation steps are described. Here, the activities for the application of 3Di in general and the activities that were done particularly for the Trial are distinguished.

4.1.1 Technical integration of 3Di in DRIVER+ (Test-bed and Socrates OC)

The 3Di instrument consists of several technical components which make it possible to use 3Di operationally during crisis management. Figure 4.2 shows three important elements that are available to use 3Di live from every location with an internet connection.

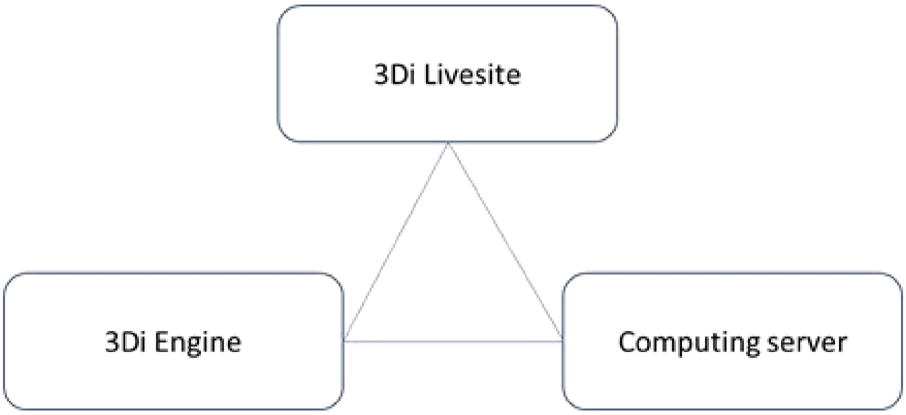

Figure 4.2: General architecture 3Di instrument making it possible to calculate in the cloud.

The 3Di engine entails the code to compute water flow in 1D and 2D for flooding, drainage and other water management studies. The engine is based on state-of-the-art numerical schemes. The engine makes use of a so-called subgrid method. This technique includes high resolution information in coarse resolution computations. This guarantees both accuracy and efficiency. The 3Di engine includes a whole range of processes, including surface run-off, 1D and 2D surface water and groundwater flow. Moreover, it can deal with 1D sewer flow and structures like pumps, weirs and culverts. 3Di deals with numerous external inputs, like precipitation from radar images and wind[16].

The 3Di Livesite is the user interface to run a 3Di model and allows users to interact with the model during a simulation. On the Livesite users are able to interactively influence the simulation by changing the rainfall, wind force and model components like cross-sections, breaches and pump capacities. Through the Livesite connections are available with computing servers. The computing server delivers the computation power that is needed to run the model. This connection makes it possible to use 3Di models from every place with an internet connection. The only recommended software to be installed before using the 3Di livesite is the Google Chrome Browser.

In Trial 1 the 3Di Livesite was the user interface available for practitioners. The use case for integration of the Test-bed and with Socrates OC was about sharing information for situational awareness during the crisis management situations and sharing information about the effect and design of measures to mitigate the consequences of a flood.

The 3Di Livesite provides the option to export (store) results of a model run. The results of a model run are stored in a NetCDF-file. The NetCDF is written according to the CF conventions[17]. Through the 3Di – API it is possible to download the NetCDF-file. For the GIS software QGIS a 3Di plugin is developed to read and use the NetCDF file.

The most used possibility to store and visualize the results of a model run is through the information platform Lizard and its API. Within this route the NetCDF with raw data is made available in the user interface of Lizard[18]. From Lizard and its API it is possible to export data in different formats. The WMS is under development and was not available for the Trial (Figure 4.3 sketches the possibilities offered by 3Di to export its results).

---

[16] The 3Di engine is developed by Prof. dr. ir. G. S. Stelling, who worked on the subgrid technique in close collaboration with Prof. dr. ir. V. Casulli. Most of the techniques used within the 3Di engine are published in scientific papers.

[17] See for more information: http://cfconventions.org/.

[18] Lizard is an information portal that processes all kinds of (big) data needed for water related issues. https://world.lizard.net.

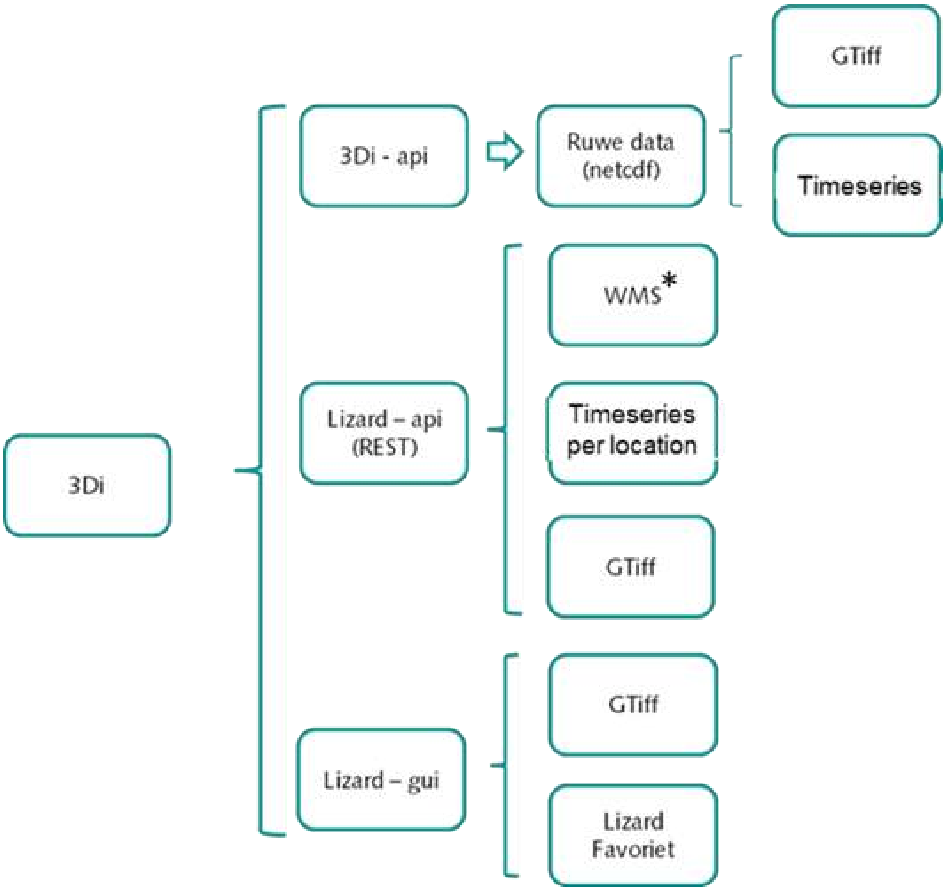

Figure 4.3: Possibilities to export 3Di results.

The ambition for Trial 1 was to integrate 3Di into the Test-bed and to make the 3Di results available in Socrates OC. During Dry Run 1 a first design of the architecture was available. During Dry Run 1 and in the weeks after a special GeoServer was set up to make the transfer of GeoTIFF files with 3Di results possible. The aim was to send the GeoTIFF file with the maximum water depth levels of a model run on a decisive moment. The corresponding workflow was illustrated in Figure 2.7.

During Dry Run 2 the connections were functioning as designed. However, the time of uploading of the large GeoTIFF files was much longer than expected. Therefore the decision was made to leave the transfer of GeoTIFF files out of the test-Trial[19] and the Trial 1. It was at this point and within this timeframe not possible to develop a better connection. It is possible that the WMS export format, which is in development, will make this a lot easier.

During the test-Trial the information flow between 3Di/Lizard and the Notification Web-app, Test-bed and Socrates OC was a message to send when the practitioners finished a model run worth to share. The practitioners with 3Di available had the task to decide whether the information from 3Di was helpful to share to increase the COP of all stakeholders. During the test-Trial in Dry Run 2, this workflow was successfully tested.

4.1.2 Building the 3Di model for the area of interest

To make use of the 3Di instrument a model needs to be available of the area of interest. The very first step in the preparation of the Trial was to build a 3Di hydrodynamic model of the area of interest. In Figure 4.4 the workflow is visualized to build a 3Di model. Here, it is presented as a straight line while in reality constant iterations are made to test and improve the model.

[19] The “test-Trial” was a simplified rehearsal of the Trial execution which was performed during Dry Run 2.

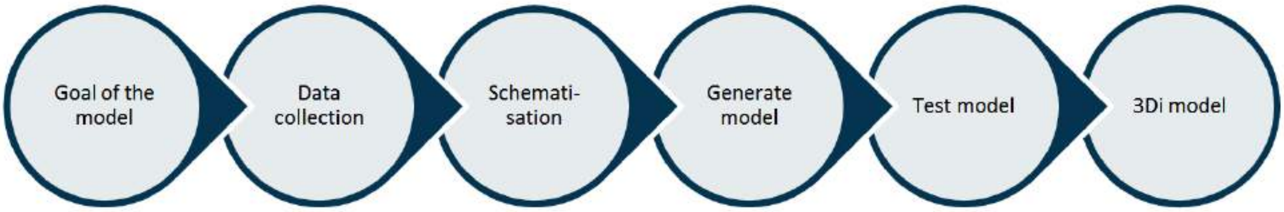

Figure 4.4: Steps to take to build a 3Di model

The first step to determine the goal of the model is an important step. The goal of the model determines the functions that are used and determine the critical data requirements. For Trial 1 the goal was to test the usability of 3Di during decision-making. Therefore, it was important that the model gives a good impression of the flood zones and the model is fast enough to use it interactively. In case of this flooding model, a sewerage system for example can be left out of the model since it will not make a difference on river floods.

Most of the data required to build a 3Di model is geo information (e.g. raster data, 1D elements). For the collection of data and the schematisation GIS knowledge and software is needed. The GIS package that is used to build 3Di models is open software QGIS. In QGIS an especially designed 3Di plugin is available for support.

Within a 3Di flood model the resolution of the Digital Elevation Model (DEM) determines for an important part the accuracy of the model. Since this was a test case it was decided to use the already available ASTER Global-DEM with a 30 by 30 meter resolution, which is available worldwide. In order to improve the results of the model this DEM was interpolated into a 5 by 5 meter resolution. Furthermore, the schematisation was used to make the results as realistic as possible. Before Dry Run 1 the following components were added in the 3Di model:

1. Creating a fictive dam in the river Narev at Debe.
2. Creating a fictive dam between the river Narev and the river Wisla at Nowy Dwór Mazowiecki.
3. Creating levees alongside the river Narev.
4. Creating an initial water level in the river Narev.

During Dry Run 1 the model was demonstrated and tested. In regular modelling building practices the goal of the model is evaluated and local knowledge on the area is used to improve the model. In this case the ones responsible to make the crisis scenarios during Trial 1, the Trial Owner, set the starting points and assumptions for the model. The following adjustments were made in the model after Dry Run 1:

1. Adjusting geographic extent model.
2. Adjustment DEM interpolated to 5x5m.
3. Adjusting friction within the riverbed to 0.035 (to simulate mud-like fluid).
4. Creating a dry waterbed.
5. Adding three breach locations.
6. Moving the dam at Debe to Zegrze.

4.1.3 Scenario configurations

3Di offers a range of possibilities to alter and configure the 3Di model to calculate the result of specific scenarios. This is both possible in the settings of the model and possible on the live site. Several options are available to configure particular scenarios within the 3Di model. In Figure 4.5's screenshots two options are given: how to adjust forcing on the model (rain, a positive or negative discharge point and wind) and how to open and close breach locations. The latter was mainly used during Trial 1.

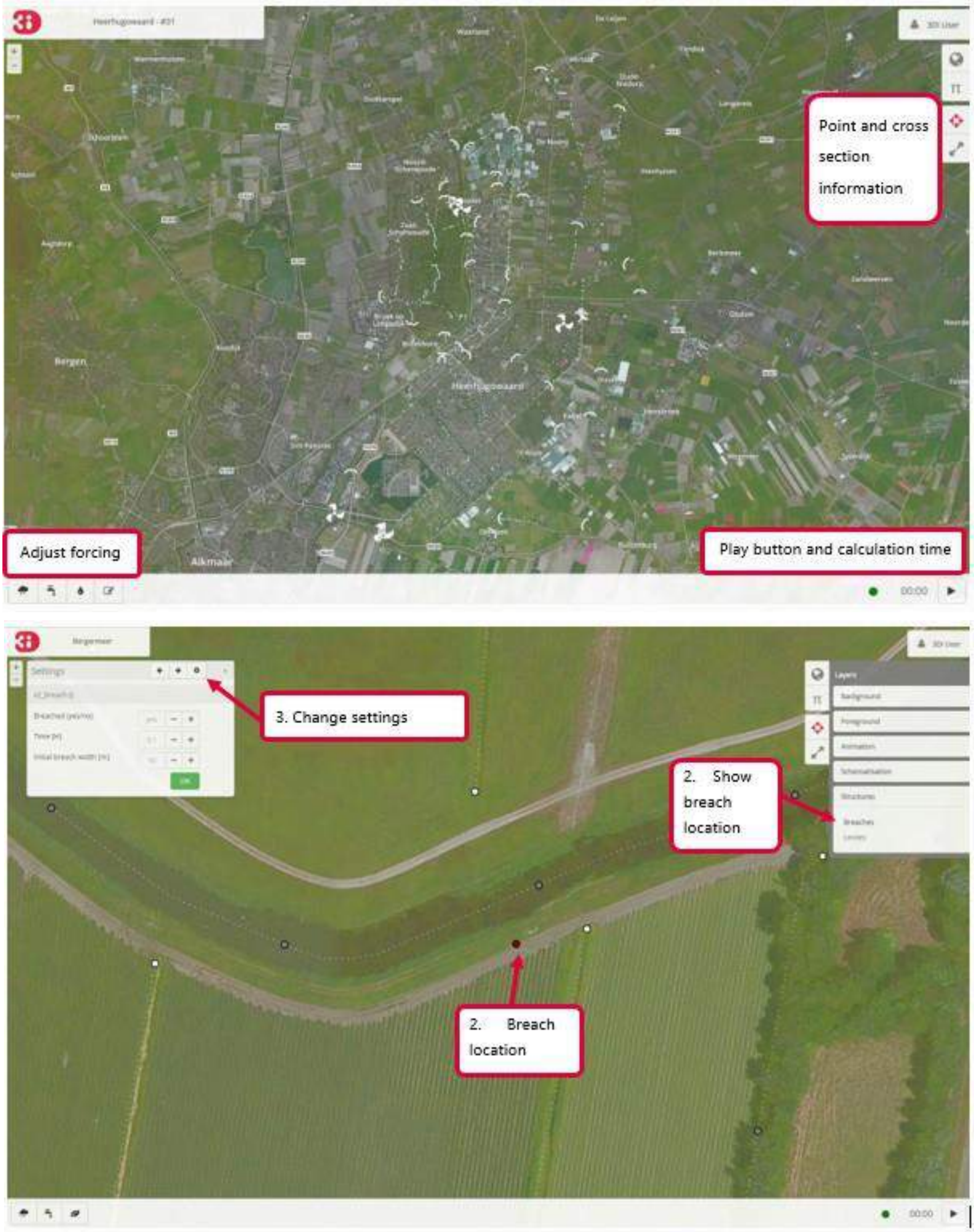

Figure 4.5: Two print screens of the user interface of the 3Di live site, where is shown how to adjust forcing on the model and how to work with breaches in the model.

In order to support the scenario of Trial 1 and to make it possible to test 3Di in the given timeframe of the Trial the model was configured on the scenario. The most important adjustments were adding particular breach locations after Dry Run 1. After testing the scenario story and the model in Dry Run 2, an extra breach location was added to the model. Furthermore, in between Dry Run 1 and Dry Run 2, two instances of the model were created. One instance was developed where the flood started with a breach in the dam and one instance was set up, where the flood already reached areas nearby the town Gora. By skipping the time in between these two events, the practitioners had more time for analysis and fulfilling their task to determine the order of evacuation and testing the added value of dynamic flood information from 3Di.

4.2 Solution usage in Trial 1

During Trial 1 3Di was used to get an overview of the flood pattern of the chemical spill. One team of practitioners had 3Di available to decide on the evacuation order of selected buildings while the other team did not have 3Di available. The aim of the Trial was to test the operational use of 3Di during a Crisis Management situation, and whether 3Di could support the crisis managers in their decision making process on evacuation. In this Trial 3Di was used as an independent operating system. The connection with Socrates OC and the Test-bed were not finally used during the Trial 1 execution, although an example of interaction was shown to practitioners during the Socrates OC sessions.

The team which had access to 3Di worked along a two-step strategy to determine which buildings had to be evacuated and in which order:

1. Determine the priority in terms of risk of the designated buildings
2. Determine the order of evacuation by priority and expected arrival time of the water

<u>Step 1: Risk of designated buildings</u>

The team used a standardized method to determine the risk for each of the designated buildings. For each of the buildings the team weighed the risk following the formula:

Risk = Height * Exposure * Vulnerability

Height = height difference between highest water level in proximity of building and elevation of building, or time of first arrival of water

Exposure = number of persons present

Vulnerability = mobility of affected persons and/or vulnerability or importance of building

3Di was used as an information source to determine the Height. The team simulated about half a day of the flood and processed those results to Lizard, in which they located all the buildings and determined the height difference between the highest water level in the proximity of the building and the elevation of the building (Height) per location. In the determination of the Height, the team took into account that models are always an approximation of reality, meaning that the actual water level might be higher or lower.

The number of persons present per building (Exposure) was not provided in the Trial. Depending on the time of day and the use of the building, the team assumed whether people would be present in the building or not. For example: people will only be present in a school during school hours and not at night, while a hospital will always contain people. Therefore, if the water reaches a school during night time, it will not need evacuation since no persons will be present at that time. The time needed to evacuate a specific building or the availability of vehicles was not considered in this Trial.

In the Vulnerability both the mobility of the people present and the vulnerability or importance of the building were taken into account by the team. For example: the team assumed that people in a church will be able to evacuate themselves if given a long enough notice, while people in a hospital will always require assistance. Furthermore, some buildings are important to protect, especially when they have a high economic value.

Using all three variables the team determined the priority in terms of risk for all buildings, focusing on the buildings in the proximity of or in the flooded area (Figure 4.6 shows a picture taken while the team was working on determining the risk).

Figure 4.6: The team working on determination of the risk in Trial 1

<u>Step 2: Order of evacuation</u>

The team determined the order of evacuation by combining the risk of designated buildings as determined in step 1 with the arrival times of water as present in Lizard after processing of the 3Di results (see Figure 4.7). First the flooded areas were considered, taking water arrival times and speed of water depth increase into account, second the buildings close to flooded areas were considered. Using both those steps the team decided on which buildings to evacuate and in which order.

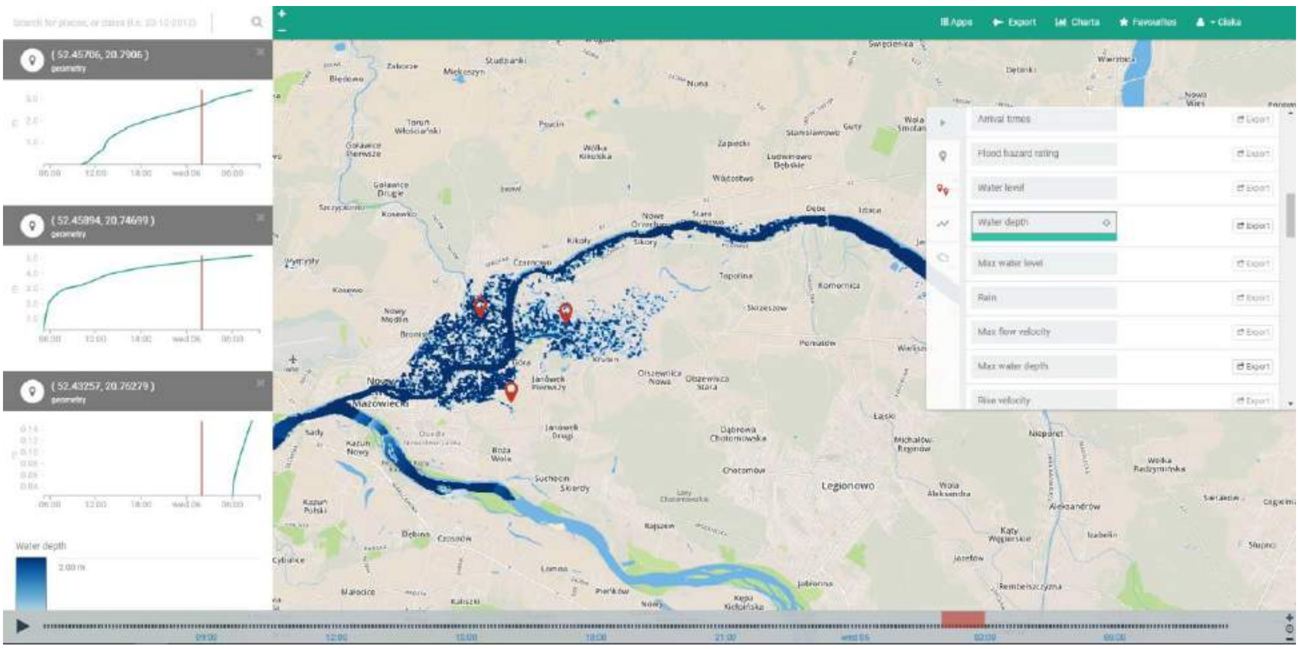

Figure 4.7: Water depth as shown in Lizard after processing of 3Di results, with three marked locations

5. Application of Drone Rapid Mapping (DRM) in Trial 1

Currently the use of drones during crisis situations is incidental (however of a growing popularity) and focused on real-time video capabilities. These capabilities are of a high value for improved initial understanding of the incident scene and its dynamics as well as for monitoring of specific elements of tactical situation.

However, video imagery is suboptimal for general awareness of larger-scale situation and for understanding of a general topography of the crisis area. For such purposes, the recently discovered orthophoto map is a significantly more effective form of presenting imagery information.

The Drone Rapid Mapping enables access to up-to-date spatial information about the area of interest, its topography and changes resulting from the on-going crisis. It significantly improves situational awareness of higher-level commanders and it enables larger-scale damage assessment. It can also be used as reference information at the tactical level.

While information about current situation (e.g. distribution of vehicles or extent of water during flooding) is not real-time, it can still be used as an approximation and the map can be regularly updated. Furthermore, a map is highly more intuitive than video for persons not familiar with the area (following video from a flight most commonly leads to loosing spatial orientation). Therefore, the orthophoto map seems to be an optimal form of presenting spatial information.

The sharing of such maps should contribute to improved common operational picture and more effective coordination, particularly at silver command level. They can also be used for reporting of general situation at strategic level.

Drone Rapid Mapping solution offers quick generation of the orthophoto maps and 3D visualisations of incident/crisis area (see Figure 5.1 for an example of orthophoto map based on raw drone images). It processes data acquired by any kind of RPAS available to rescue or crisis management actors, that is capable of capturing nadir (vertical) imagery and can be programmed for autonomous flight mission.

Figure 5.1: Comparison: raw data used for processing (on the left) and orthophoto map product (on the right)

The orthophoto map is instantly displayed on all connected geoportals and COPs and easily shared among others for the purpose of:

- Providing the Incident Commander with visualisation that can be further used inside any COP.
- Aiding the responders´ vehicles to navigate through rough terrain with the help of the 3D model.

- Depicting damages that were caused by incident.
- Aiding the highest level of management and politics to quickly brief with the help of the 3D model. It can be also shown during press conference to help informing the population.

Due to very efficient method of processing, the product might be utilised during the response phase of the Crisis Management cycle. Generation of maps is enabled by the use of cloud computing.

The previously validated[20] efficiency was:

- Mapping of 10ha with 2cm pixel and Long Term Evolution (LTE) internet access requires at least 26 minutes.
- Generation of the high quality 3D model requires at least 20 minutes (processing time might differ depending on requested quality of product)

This timing covers all activities: mission request (crisis manager's briefing for a drone operator), flight preparation, conduct of the flight, landing, data retrieval and upload, all calculations, preparation of geoportal content

The resulting primary product (orthophoto maps) of the DRM solution can be viewed online via standard internet browser without any additional software required. In that case, it is displayed in a dedicated geoportal (considered as a part of the solution). It can be also easily integrated with any other GIS environment with the use of WMS service (see for instance Figure 5.2). Lastly, it can be also downloaded for further processing.

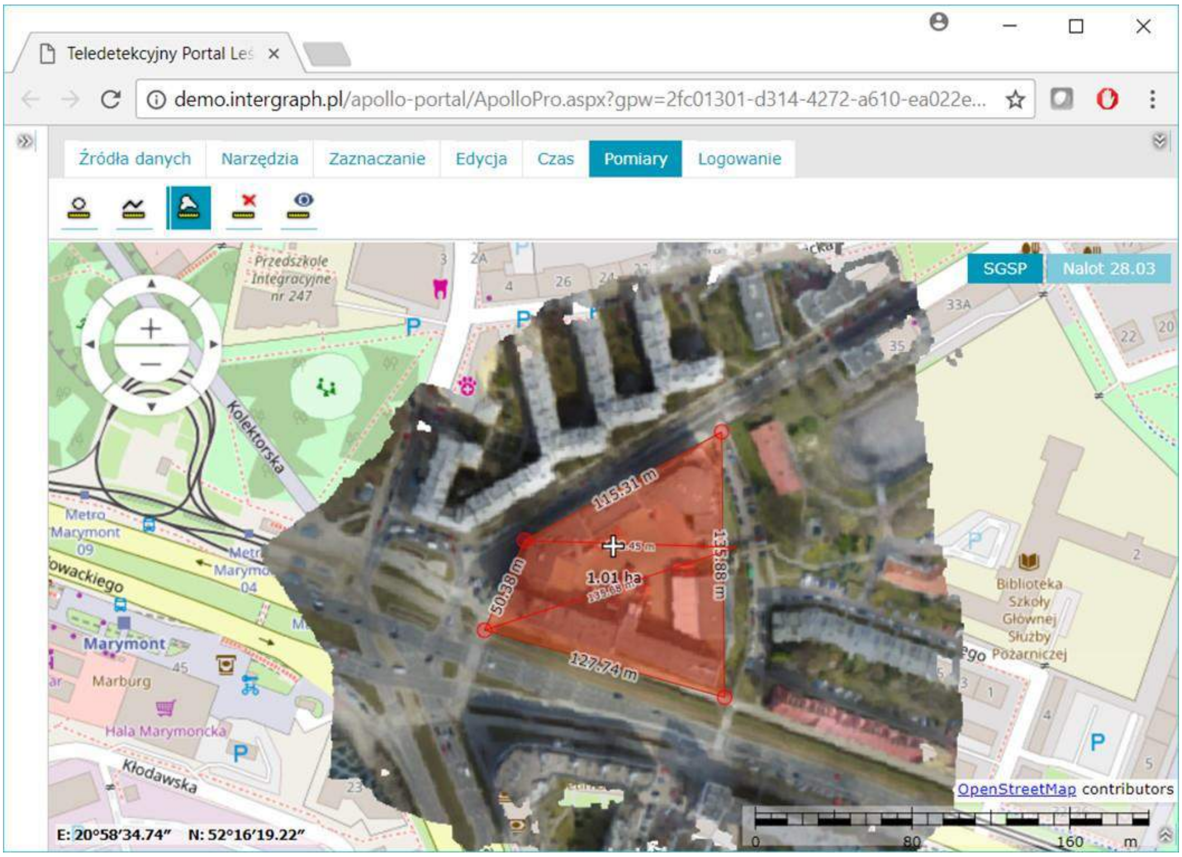

Figure 5.2: Orthophoto map prepared during DR1 for testing purposes. One pixel size = 1,8cm. Map is displayed on Solution provider's online viewer

This flexible approach encourages a wide range of possible applications, from basic users up to specialised agencies.

[20] Displayed efficiency was recorded during State Fire Service Interregional Exercise in Janowskie Forests, 28-29.06.2017.

In addition to the basic product a 3D model of the terrain could be generated as well. The model bases on the same set of data (photos), however its generation takes additional time. A 3D visualisation of terrain enables better and more intuitive understanding of the area of interest. It can be generated as .OBJ or .KMZ files.

The 3D visualisation can be viewed in any 3D viewer capable of opening .OBJ files (see Figure 5.3 and Figure 5.4 for two examples).

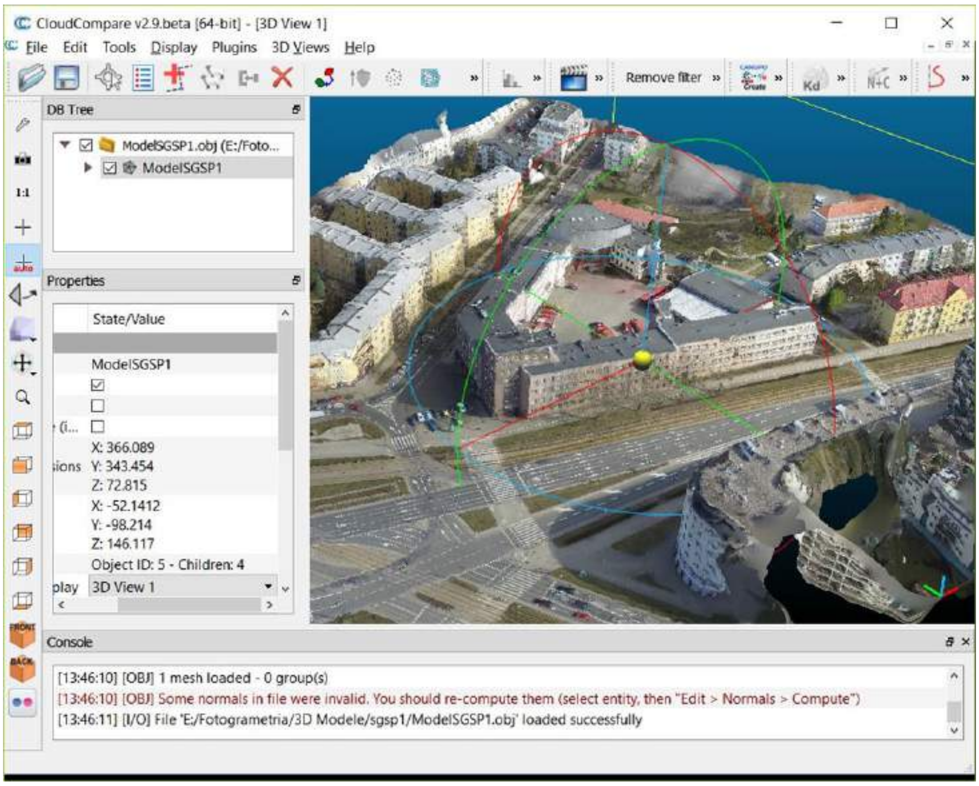

Figure 5.3: 3D .OBJ model displayed in Cloud Compare

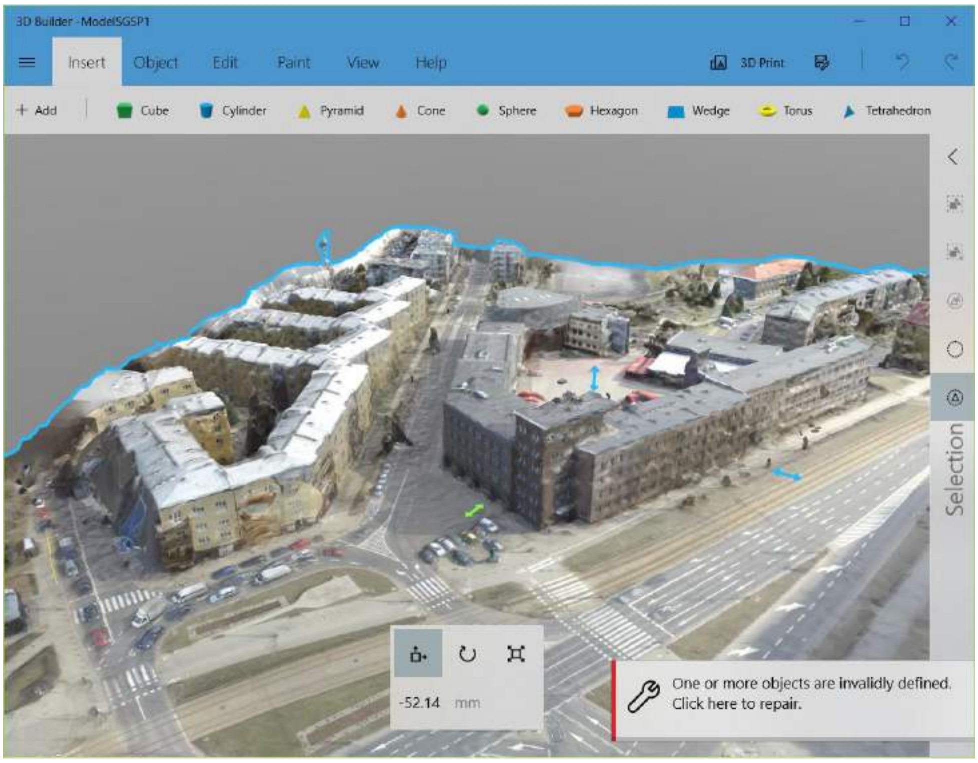

Figure 5.4: Model displayed in 3D Builder application (default app pre-installed in Win10)

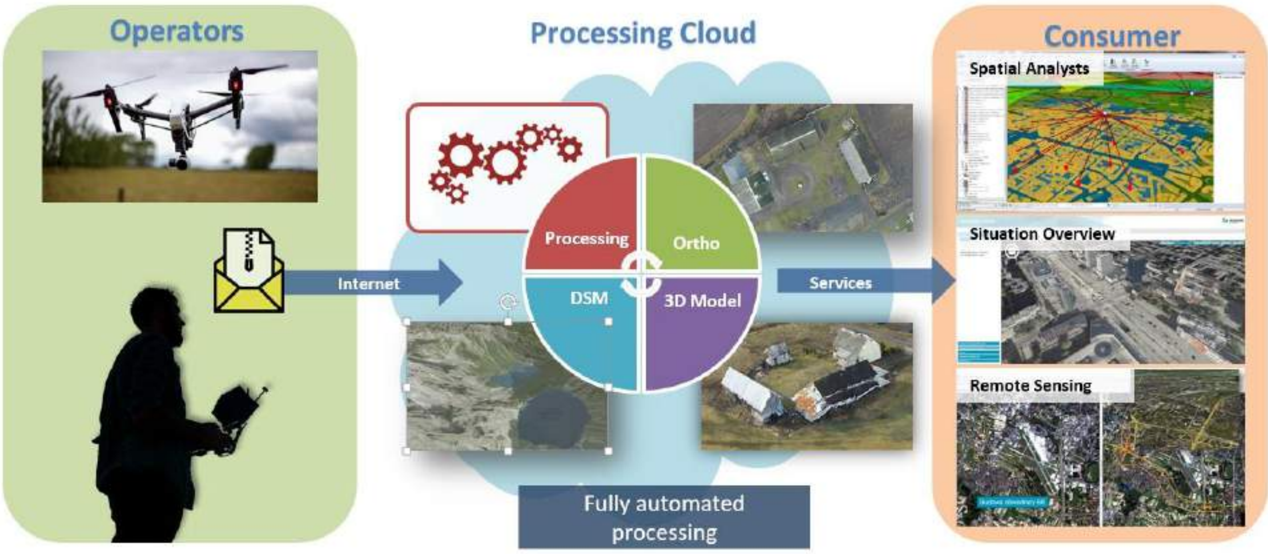

Figure 5.5: DRM simplified work scheme

Figure 5.5 shows the general work scheme associated to the DRM solution. The typical steps involved in the solution usage are as follows:

- Basic training is provided in advance to a Drone Operator, who has to learn how to download the application for autonomous nadir missions planning and how to conduct these missions. It takes about 20 minutes to complete the training[21].
- The area of interest is selected by the Incident Commander. The Drone Operator is tasked with the mission of acquiring data basing on three values: flight height and vertical and horizontal overlay.
- The mission is done and data can be transferred to any kind of PC with internet connection.
- The data is sent to the DRM server and the processing starts.
- Once processing is finished, the Incident Commander and other Crisis Management staff receive the notification about products which are ready to be directly displayed or available for download.

The Drone Rapid Mapping approach to support Crisis Management operations has been developed and tested by a group of Polish entities: the Crisis Information Centre of the Space Research Centre, Creotech Instruments, Hexagon (Safety and Infrastructure) and CloudFerro.

DRM solution provider recommended the following user story for the usage of their solution in Trial 1.

Generation of an orthophoto map and a 3D model in order to:

- Measure the reservoir embankments (simulated by harbour entrance) – determining the range and extension of the levee breach (damage assessment, collection of data to measure levee breach) without risk of injures.
- Determine the range and extension of toxic spill (environmental damage assessment).
- Find the best location for pumps and spill barriers location in a short period of time.

Solution shares data as standard georeferenced map images, e.g. WMS, or displays it on own, dedicated Geospatial Portal.

5.1 Preparation activities

There were no technical adaptions required for the usage of the solution in Trial 1. However, there were a series of pre-requirements and preparation activities needed to be done to operate the solution.

[21] It has to be noted neither RPAS nor autonomous flight software are a part of DRM solution.

RPAS must be operated by qualified operator. Moreover, the operator has to comply with Polish laws and regulations on the commercial usage of drones. In Poland, drone flights are only allowed within the visual distance (Visual Line Of Sight – VLOS). A special approval from Polish Air Navigation Services Agency and further phone confirmation before the flight to the airport control tower is needed within the area of 5km from airport. It is not allowed to flight closer than 1km to the airport. Maximum allowed altitude for drones in weight range of 0.6 - 25kg is 100m (above ground level).

Due to SGSP field proving grounds were located in Controlled Traffic Region (area inside 5km radius from airport) of Warsaw Modlin Airport (IATA codename: WMI), it was necessary to apply for special approval (pol. Warunki wykonania lotu RPA w CTR EPMO), which was granted.

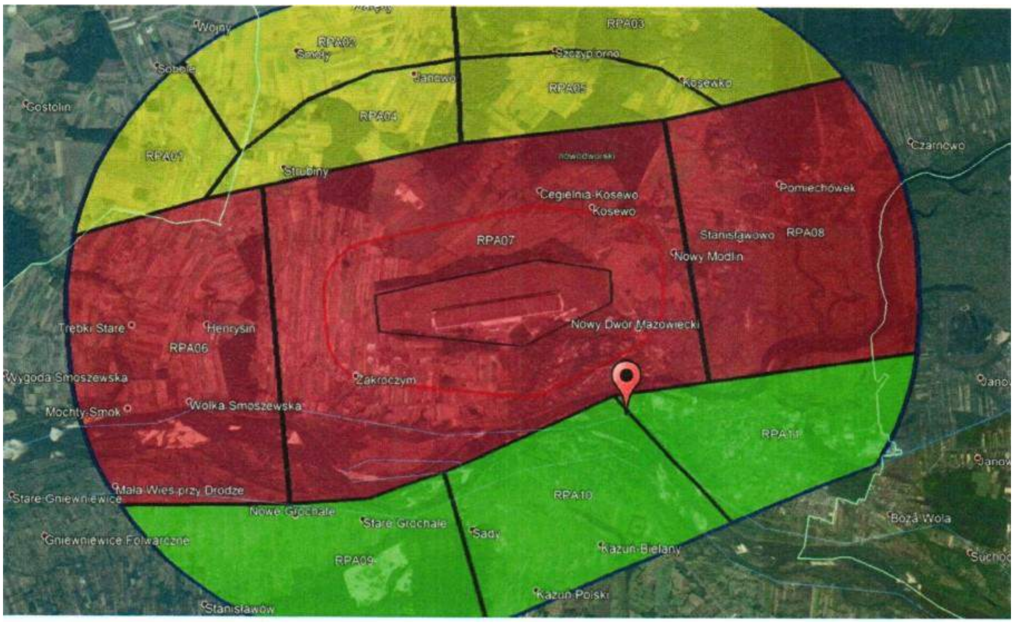

Figure 5.6: Flight areas for RPA

In Figure 5.6, green areas represent approved areas for RPA in CTR Modlin for flights on 19th and 24th of May, 2018. Each flight needed additional confirmation from TWR (Air Traffic Control). Red areas are strict no-fly zones, and yellow ones were not requested in application.

Two drone operators were selected for the mission, a cadet-officer and active firefighter from SGSP, who agreed to participate in Trial 1, and a backup pilot expressly hired by DRM solution provider for the occasion.

There were no additional requirements, as other actions, not connected with flying the drone, required only basic computer literacy.

5.2 Solution usage in Trial 1

The list of activities planned for Trial 1 regarding the usage of DRM solution is provided here below:

- Before the Trial execution:
  - Conducting a test (data acquiring, data processing) during Dry Run 1.
  - Test execution: conducting an exemplary process of acquiring the photos and creating and sharing an orthophoto map and 3D model during Dry Run 1.
  - Providing instruction materials for UAV operators in Polish.
  - Conducting 2h training and demo for practitioners.
  - Conducting refreshment training for practitioners.
- During the Trial:

  19th of May:

- Up to 15 flight missions, including two missions for KPIs and two reference missions to capture videos.
- Processing the data into map layers and 3D model for Trial on Wednesday.

24th of May:

- Flight for mission 1 (see section 5.2.1).
- Flight for mission 2 (see section 5.2.2).
- Capturing 4 episodes of SFS and providing a map layer for each one / or capturing the whole proving grounds (approximately 50ha) as one big layer (GB).
- Processing data into a) map layer and b) 3D model.
- Providing feedback to Testbed.

Table 5.1: Risks identified

Risk	Probability	Severity	Action
Weak LTE connection in exercise area.	High.	High.	A signal heat map was captured before the exercise started and the optimum place for data transfer was set up with a laptop computer and mobile data link. That place was superior to the rest of the site, however, was still below Polish average.
Weather makes the flight missions impossible.	Low.	High.	Reserve photos were collected during SFS exercises Saturday 19th of May.
Processing cloud not accessible.	Extremely low.	High.	Reserve layers and models were processed after SFS exercises Saturday 19th of May.

During Trial 1 two missions were set for DRM. Mission 1 was to simulate an attempt to remotely measure the breach in a levee of reservoir containing a dangerous substance, without risking rescuers. The breach was simulated by entrance to harbour next to SGSP testing grounds in Kazuń Nowy, Maziewckie, Poland.

During Mission 2 the whole terrain of testing grounds in Kazuń Nowy was to be flown over for attempting to locate any people that need to be evacuated from the flooded area. This was to be signalled by putting a 1x2m sheet on the building, which represented the people to be evacuated. The simulation team put a number of sheets in random locations characterised by variable visibility from air.

In both cases two types of data was collected: the reference video footage (flight height between 30 and 60m) and mosaic of photos (overlay 80%, height 100m).

Data was collected by two similar aircrafts (both: DJI Phantom 3 Standard, minor differences with propeller blades) equipped with identical sensors (built-in cameras). Both drone operators used standard imagery capturing software (DJI Firmware) as reference and “Pix4D Capture” app for autonomous imagery capture to be used in by DRM solutions.

#	Overall recorded mission time[22]	Net data acquiring and data processing time – orthophoto map	Net data acquiring and data processing time - 3D model	Net data acquiring and data processing time – WML service
Mission 1	91 minutes	62’	71’	77’
Mission 2	196 minutes (overall) 109 minutes (excluding 87 minutes pause)	83’	95’	93’

[22] Excluding purposeful delay of processing.

5.2.1 Mission 1

Mission 1 took 91 minutes (including walking between mission area and the place with best LTE connection). First result (orthophoto map) was available for download after 75 minutes from the drone start. 37% of time (34min) was consumed by data transfer via internet. Testing site offered average internet connection of ~0,35MBps – well below average polish 3G/LTE speed (0,96MBps[23], average 3G/LTE speed connection would improve the transfer time to 12 minutes).

Also, that internet connection speed was achieved only from one point 250m distant from Mission 1 operator position, with caused further slowdowns (7 min). 4 minutes were due to compressing the data package into archive file (.7z) before sending.

After excluding external factors, optimal Mission 1 time that is achievable for DRM in set conditions, is 36 minutes for orthophoto map, 45 for 3D model and 54 for WML service being available. Timewise, for further improvements, it is advised to automatize the process of data processing. The solution provider agreed to implement the recommended automatization process.

Figure 5.7, Figure 5.8 and Figure 5.9 show output products from Mission 1. More concretely, the first one provides a photo of the levee breach together with the corresponding size measurements. The second one shows an orthophoto map overlaid on Open Street Maps in the web browser of the solution provider. Finally, the last one shows a 3D model of the terrain used during Trial 1's session with DRM solution.

As an important note, it has to be taken into account that during Trial 1, due to intensive aircraft traffic in the area, both drone pilots were denied (by local Air Traffic Controlee) the permission to fly over the Narew river, which drastically lowered the quality of collected data (data was collected only from harbour side, lowering below expectance the number of nadir imagery from area northbound from port entrance). This risk is typical for Poland, as the drone flights are taken much less seriously than other aircrafts by Air Traffic Control.

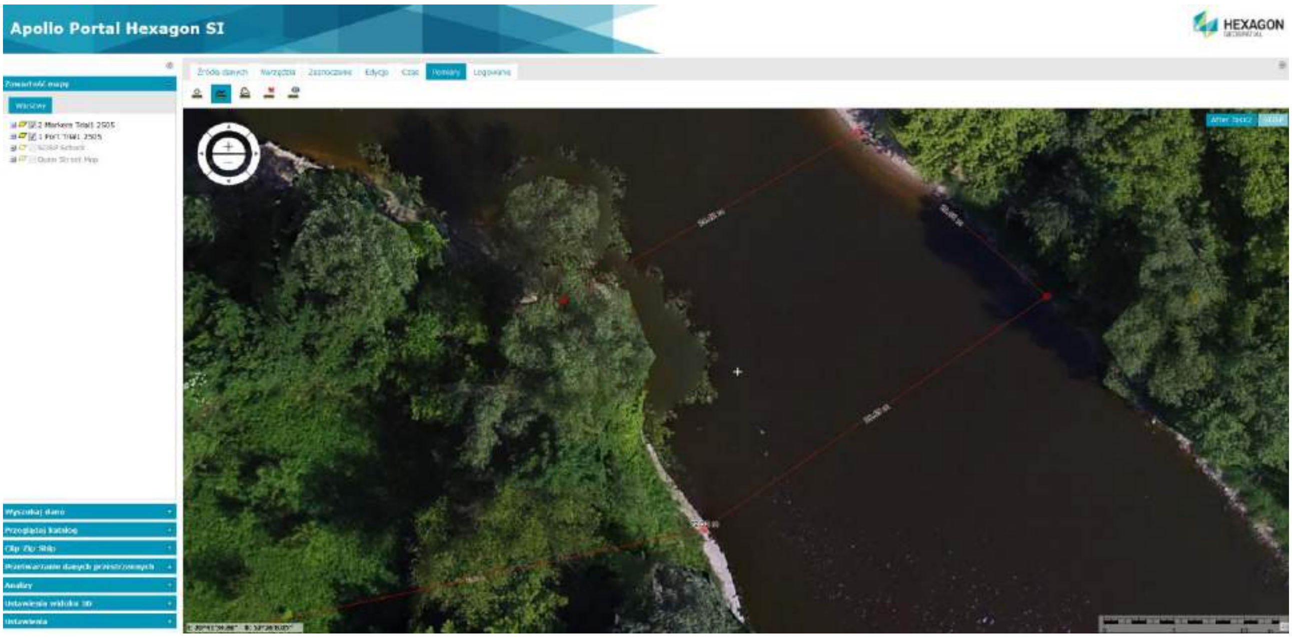

Figure 5.7: Levee breach together with measurements, maximum zoom, 1 pixel = 4,1 cm.

[23] Statistics from e-speedtest.com, article: mobile internet providers in Poland http://www.speedtest.pl/ranking_isp/5/ranking_mobilnych_dostawcow_internetu_w_polsce, retrieved 28.05.2018.

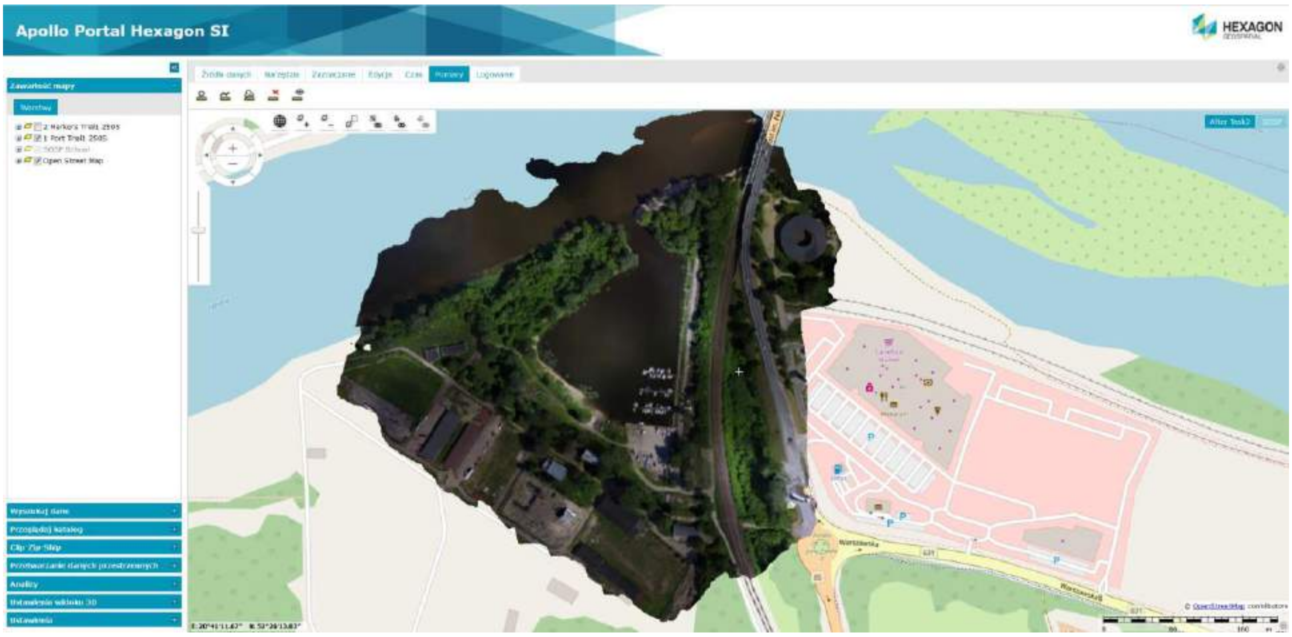

Figure 5.8: Orthophoto map provided for Mission 1, overlaid on Open Street Map, displayed in Solution provider´s web browser

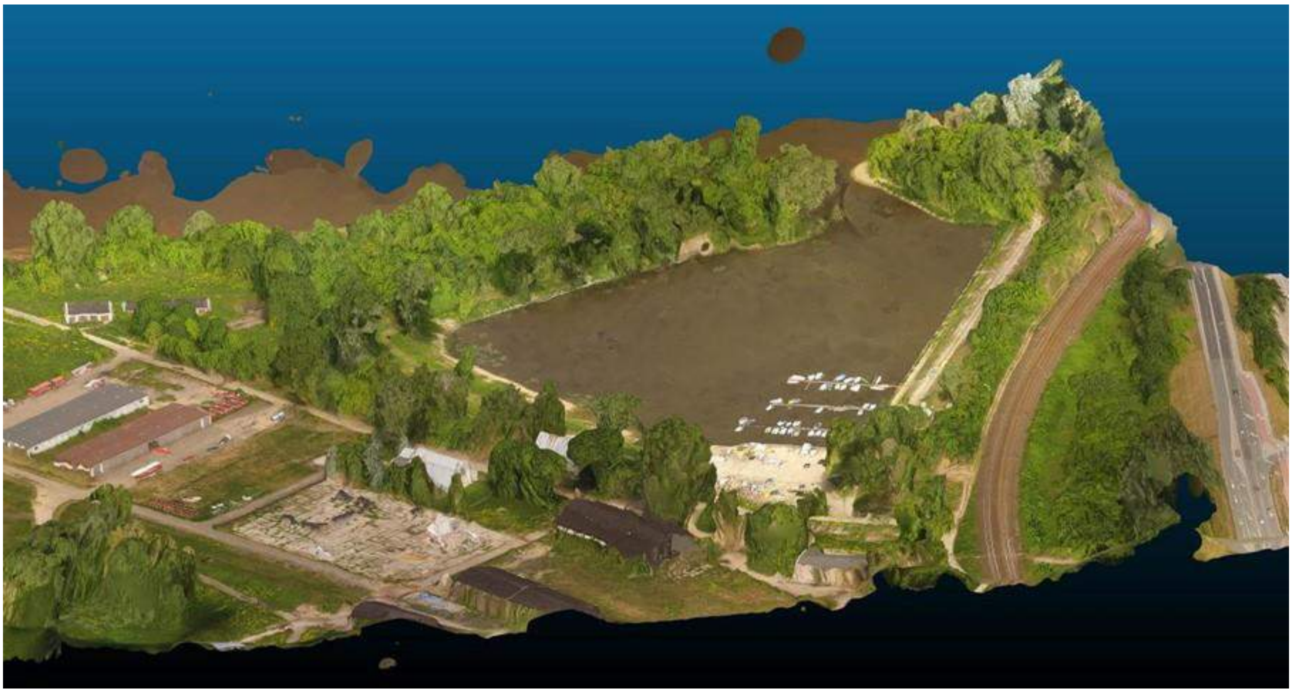

Figure 5.9: Image rendered out of 3D visualisation processed as one of results of Mission 1

5.2.2 Mission 2

As it was said, Mission 2 consisted of flying over the whole terrain of testing grounds in Kazuń Nowy (see Figure 5.10 for the complete orthophoto map resulting from this flight, and Figure 5.11 for a 3D model render of it) in order to locate people needing to be evacuated from the flooded area.

Figure 5.10: Orthophoto map – result of Mission 2

Figure 5.11: Another render of Mission 2 3D model

Endangered people were represented by sheets (or markers) on the buildings, as it is illustrated by Figure 5.12 (a 2D image showing two sheets; a blue one displayed flatwise and a red one placed vertically on a garage roof) and Figure 5.13 (a 3D model render showing a dark-blue sheet).

Figure 5.12: Zoom-in – Garage roof with 2 markers (sheets) – blue displayed flatwise, and red attached vertically

Figure 5.13: Close up for vertical dark-blue marker (3D model render)

Those sheets were put by the simulation team in random locations characterised by variable visibility from air. Some of those locations also included elements which might have been mistaken with the marker sheets in case that less accurate technique had been used (see for instance blue objects in Figure 5.14).

Figure 5.14: Multiple landscape elements which could have been mistaken with marker sheets

Mission 2 took 95 minutes, 53% (52 min) of which was consumed by data transfer via internet (reasoning as in Mission 1 in section 5.2.1, average Polish data transfer speed would shorten the transfer by 32 minutes). Also, 500m distance between Mission 2 operator position and data drop point caused further slowdowns (15 min). First result (orthophoto map) was available for download after 83 minutes from drone start. Processing was oriented on providing 3D model quicker, by slightly delaying provision of orthophoto map. WML publication was started by hand just after the orthophoto map was ready, in the interim to 3D model processing.

After excluding external factors, optimal Mission 2 time (from start to end) that is achievable for DRM in set conditions, is 51 minutes for orthophoto map, 63 for 3D model and 61 for WML service being available.

As it can be seen, external factors, such as drone pilot proficiency, time to transfer the data from memory card to computer and from computer to server have substantial impact on processing time. On the contrary, the DRM processing bases on requested quality (which for time-sensitive missions are set on low-medium level), and the processing time depends only on number and resolution of images that are uploaded. Therefore, the first step to improve the solution is to reduce delays caused by human factor and plan accordingly to internet connection (which has the strongest influence on the time the DRM products are being delivered).

Unfortunately, the mission set up selected by Trial Owner was dissuaded by the solution provider, as it surpasses the typical utilisation of DRM. It was communicated during DR1 and DR2 that firstly: algorithms of DRM are set to automatically clear away moving objects (like sheet moved by wind) and also that due to data collection method that is used for solutions, not angled photos are gathered, thus finding relatively small markers displayed vertically is highly improbable and exceeds solutions capabilities. Also, the reasoning of using the solution in episode that is oriented on Search and Rescue is dubious.

It has to be noted that, in addition to Mission 2, other sub-missions were performed in order to provide additional detailing into 3D visualisation. However, due to very low internet upload speed, it was decided not to transfer those additional photos and process a 3D model of given area of interest based only on Mission 2 data.

Figure 5.15 shows the report produced by DRM solution for the two missions performed in Trial 1. It includes the processing times for the generation of the output products associated to those missions.

Driver+ Trial1 - processing report

Mission date: 24.05.2018

HEXAGON SAFETY & INFRASTRUCTURE

Task	Flight Info	Processing Stage	Timestamp	Time diff	Time SUM
1. Port	*Photos: 137 (22.4 ha)*	Start	11:00:55		
	Flight height: 100m (GSD 4.1cm)	Alignment	11:03:45	00:02:50	00:02:50
	Overlap: 80%/80%	Point Cloud	11:07:50	00:04:05	00:06:55
	Processing: Fast	Mesh	11:10:05	00:02:15	00:09:10
		Ortho	11:13:11	00:03:06	00:12:16
		Ortho output	11:13:50	00:00:39	**00:12:55**
		3D Texture	11:22:30	00:08:40	00:21:35
		Mesh output	11:23:01	00:00:31	**00:22:06**
		Portal Publication (manual)	11:29:00	00:06:30	00:28:05
2. Markers		Start	13:08:05		
	Photos: 205 (32.2 ha)	Alignment	13:12:45	00:04:40	00:04:40
	Flight height: 100m (GSD 4.1cm)	Point Cloud	13:18:30	00:05:45	00:10:25
	Overlap: 80%/80%	Mesh	13:22:58	00:04:28	00:14:53
	Processing: Fast (Mesh MED)	Ortho	13:27:25	00:04:27	00:19:20
		Ortho output	13:28:22	00:00:57	**00:20:17**
		3D Texture	13:39:50	00:11:28	00:31:45
		Mesh output	13:40:10	00:00:20	**00:32:05**
		Portal Publication (meanwhile)	13:38:15	00:10:50	00:30:10

Figure 5.15: Trial 1 DRM processing report

6. Conclusion

This document has presented the main activities related to the application of solutions to Trial 1, focusing on the adaptions and activities which were required to prepare the solutions for the Trial (across the whole Trial process) and their final usage in the Trial execution.

The overall impression of the solution providers about Trial 1 was, as it was said in the beginning, quite good. They found it as a good opportunity to give visibility to their solutions in a European context, to cooperate with other solution providers in the Crisis Management domain and gather valuable feedback from practitioners and experts in different fields and from different countries across Europe.

There is however a series of lessons learned (drawn from the solutions perspective) which reveal some aspects to be improved and, in the opinion of the solution coordinator of the Trial, are worth to be taken into consideration for the next Trials:

- In general, the Trial 1 schedule was perceived as too tight by solutions providers. The task to implement even small adaptions is usually complex; one month between the initial acceptance of solutions and Dry Run 1, and three weeks between Dry Run 1 and Dry Run 2 might be not enough in many cases.
- Required adaptations (especially in the case of the "internal solution" which participated in the Trial) were very demanding and not enough validated.
  An earlier definition of the Trial scenario, research questions, data collection and evaluation plans and the needed adaptions of the solutions would be required, and only minor modifications should be allowed during the rest of the process.
- Not enough information was distributed to solution providers in the Call for Applications nor during the initial acceptance of solutions (cf. section 2.2 for an outline of the Trial 1 process). The information about the required interoperability capabilities of solutions was not well defined and no detailed information about the Test-bed was provided in advance. This mainly impacted external solution providers, and had the following consequences:
  - The formal commitment by external solution providers (and so their start of the work) was not achieved until one week before the Dry Run 1 (this led to an even tighter schedule).
  - External solution providers had difficulties to gain the knowledge to prepare the integration in the required timeline.
  - The technical integration with the Test-bed could not be achieved during Dry Run 1, as it was expected.
- The solution integration and validation process for approval at DR1 and DR2 needs to be better defined and monitored. It has to be also realistic and achievable, given the corresponding Trial timeframe.
  The solution providers should be informed well in advance about:
  - The preliminary technical and interoperability requirements for participating in Trial 1 (i.e. the requirements to connect to the Test-bed and the kind and format of the data to be exchanged), as agreed by the Trial Committee, and their responsibility for meeting user stories (end user requirements), which the initial solution acceptance is based on.
  - The adaptions to be made on their solutions (if any), as required by the Trial Owner or practitioners, as well as the deadline for the readiness of solutions.

  It would be also highly desirable to set up an infrastructure which allowed running remote testing at least between the initial acceptance of the solutions and the Dry Run 2.
- None of the solutions which were initially selected were discarded in the Dry Run 1 or Dry Run 2. However, this is a possibility according to the Trials methodology. Being this the case, the possibility of having their solution discarded should be communicated to the solution providers in a transparent way at the very beginning of the process, and the criteria to do it should be clearly

defined (e.g. not achieving the integration with the Test-bed at some point during the process, not fulfilling the agreed requirements or user stories, etc.)
Specific checklists could be elaborated for the main milestones of the Trial process (e.g. the Dry Runs). Additionally, contingency plans should be elaborated in advance in order to deal with the situation of discarding a solution at a late stage of the process (e.g. at Dry Run 2), as it might have a major impact in the Trial scenario and the performance of the other solutions.

- Some aspects of the technical set-up, such as the bandwidth of the Internet connection in the exercise area, should be more carefully assessed before running the Trial, in order to guarantee that every solution (and thus the Trial scenario) can perform as expected.

Apart from these aspects to be improved, the overall impression of the solution providers about Trial 1 was quite good. Putting aside some technical issues as mentioned, the different sessions with the solutions ran smoothly and the interaction of practitioners with solutions even exceeded the expectations.

References

1. **DRIVER+ consortium.** *Description of Work - DRiving InnoVation in crisis management for European Resilience.* 2017. 7th Framework Programme of the European Commission. Grant agreement no.: 607798.

2. **DRIVER+ project.** *D943.11 - Report on Trial Action Plan - Trial 1.* 2018.

3. —. *D934.31 - DRIVER+ Solution scenarios and integration test results v1.* 2018.

4. **ISO.** *Societal security - Emergency management - Message structure for exchange of information.* s.l. : ISO, 2015. ISO/TR 22351:2015.

5. **DRIVER+ project.** Test-bed specification. [Online] 2018. https://driver-eu.gitbook.io/test-bed-specification.

6. —. Test-bed design. [Online] 2018. https://driver-eu.gitbook.io/test-bed-design.

7. **The Open Source Geospatial Foundation (OSGeo).** GeoTIFF. [Online] 2018. https://trac.osgeo.org/geotiff/.

8. **The Open Geospatial Consortium (OGC).** Web Map Service. [Online] 2018. http://www.opengeospatial.org/standards/wms.

9. —. Web Feature Service. [Online] 2018. http://www.opengeospatial.org/standards/wfs.

10. **The Apache Software Foundation.** Apache Kafka - A distributed streaming platform. [Online] 2017. https://kafka.apache.org/.

11. **DRIVER+ project.** The Java Test-bed adapter. [Online] 2018. https://github.com/DRIVER-EU/java-test-bed-adapter.

12. **The European Commission (EC).** EUR-Lex - 2014/762/EU: Commission Implementing Decision of 16 October 2014 laying down rules for the implementation of Decision No 1313/2013/EU of the European Parliament and of the Council on a Union Civil Protection Mechanism and repealing . *Commission Decisions 2004/277/EC, Euratom and 2007/606/EC, Euratom (notified under document C(2014) 7489) Text with EEA relevance.* [Online] 2014. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2014.320.01.0001.01.ENG.

13. **Lawrence Livermore National Laboratory (LLNL).** CF Conventions and Metadata. [Online] 2018. http://cfconventions.org/.

14. **Lizard Team.** Lizard World. [Online] 2014. https://world.lizard.net.

15. **Speed Test.** Ranking mobilnych dostawców Internetu w Polsce. [Online] 2018. http://www.speedtest.pl/ranking_isp/5/ranking_mobilnych_dostawcow_internetu_w_polsce.

Annexes

Annex 1 – DRIVER+ Terminology

In order to have a common understanding within the DRIVER+ project and beyond and to ensure the use of a common language in all project deliverables and communications, a terminology is developed by making reference to main sources, such as ISO standards and UNISDR. This terminology is presented online as part of the Portfolio of Solutions and it will be continuously reviewed and updated[24]. The terminology is applied throughout the documents produced by DRIVER+. Each deliverable includes an annex as provided hereunder, which holds an extract from the comprehensive terminology containing the relevant DRIVER+ terms for this respective document.

Table A1: DRIVER+ Terminology

Terminology	Definition	Source
Command & control	Activities of target oriented decision-making, situation assessment, planning, implementing decisions and controlling the effects of implementation on the incident (disaster).	ISO 22320
Crisis	Situation with high level of uncertainty that disrupts the core activities and/or credibility of an organization and requires urgent action.	ISO22300 (2015) 2
Crisis management	Holistic management process that identifies potential impacts that threaten an organization and provides a framework for building resilience, with the capability for an effective response that safeguards the interests of the organization's key interested parties, reputation, brand and value creating activities, as well as effectively restoring operational capabilities. Note 1 to entry: Crisis management also involves the management of preparedness, mitigation response, and continuity or recovery in the event of an incident, as well as management of the overall programme through training, rehearsals and reviews to ensure the preparedness, response and continuity y plans stay current and up-to-date.	ISO22300 (DRAFT 2017) 8
Dry Run 1	First rehearsal of a Trial, focusing on the technical integration of solutions, reference implementation of the Test-bed, and scenario validation; it also serves as a readiness review to approve the maturity of technical solutions.	Initial DRIVER+ definition
Dry Run 2	Full scale rehearsal of a Trial without external end-users participation, aimed at detection of technical issues and last second fine-tuning; Dry Run 2 is organised as a complete mirror of the Trial.	Initial DRIVER+ definition
Gap	Gaps between the existing capabilities of responders and what was actually needed for effective and timely	Project Responder 5

[24] Until the Portfolio of Solutions is operational, the terminology is presented in the DRIVER+ Project Handbook and access can be requested by third parties by contacting coordination@projectdriver.eu.

Terminology	Definition	Source
	response.	
Interoperability	The ability of diverse systems and organisations to work together, i.e. to interoperate.	ISO 22397
Scenario	Pre-planned storyline that drives an exercise; the stimuli used to achieve exercise objectives [pre-planned storyline that drives an exercise, as well as the stimuli used to achieve exercise project performance objectives].	ISO22300 (2015) 9 [DRAFT 2017, p 27]
Test-bed	The software tools, middleware and methodology to systematically conduct Trials and evaluate solutions within an appropriate environment. An "appropriate environment" is a testing environment (life and/or virtual) where the trialling of solutions is carried out using a structured, all-encompassing and mutual learning approach. The Test-bed can enable existing facilities to connect and exchange data, providing a pan-European arena of virtually connected facilities and crisis labs where users, providers, researchers, policy makers and citizens jointly and iteratively can progress on new approaches or solutions to emerging needs.	Initial DRIVER+ definition
Trial	An activity for systematically finding and testing valuable solutions for current and emerging needs in such a way that practitioners can do this in a pragmatic yet systematic way.	Initial DRIVER+ definition

Annex 2 – Template for Daily Report (used in Sessions 1 and 2 of Trial 1)

(NAME OF DISASTER)
Daily Report No. ______

Responsible Person:
Phone:
E-mail:

The status given here was valid at:
Date: (yyyy-mm-dd)
Time: hh/mm (local) – hh/mm (UTC)

1. SITUATION UPDATE

Area affected (attach maps if possible)

Impact

Anticipated evolution / secondary threats, short and mid-term developments

2. RESPONSE OF THE AFFECTED COUNTRY

Administrative measures

Operations

Constraints

3. INTERNATIONAL RESPONSE on BILATERAL BASES

Resources arriving on site / mobilised

Activities of deployed assets

Coordination structures

Constraints

4. PLAN FOR TOMORROW

Envisaged activities for the incoming days

5. REQUIREMENTS TO BE TRIGGERED BY THE GOVERNOR ON HIGHER OPERATIONAL, STRATEGIC AND POLITICAL LEVEL

Priority response needs (give as much details as possible: quantity, size, etc.)

Delivery: distribution system and logistics

6. MEDIA

Who is the primary contact point for media within the Crises Management Centre

Condensed summary of the situation for the Governor in order to prepare him/her for media briefing

7. OTHER INFORMATION

eg. maps, description of assets in the field, etc.