D2.11
Service Concept Specification

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List of Acronyms

AoS	Area of Simulation
AP	Access Point
API	Application Programming Interface
C&C	Command & Control Centre
CAMS	Copernicus Atmosphere Monitoring Service
CAP	Common Alerting Protocol
CMEMS	Copernicus Marine and Environment Monitoring Service
CMU	Crisis Management Unit
CP	Civil Protection
DB	Database
DCP	Decision Control Process
DEM	Digital Elevation Model
DES	Decision Support Information
EFAS	European Flood Awareness System
EFFIS	European Forest Fire Information System
EMS	Emergency Management Service
EO	Earth Observation
ESB	Enterprise Service Bus
ETA	Estimated Time of Arrival
DES	Decision Support Information
FCP	Forward Command Post
FR	First Responder
FRS	Fire and Rescue Service
FTP	File Transfer Protocol
GB-SAR	Ground Based Synthetic Aperture Radar
GDACS	Global Disaster Alert and Coordination System
GIS	geographic information system
GOI	Geographical Locations of Interest
GUI	Graphical User Interface
IA	Impact Assessment

IC	Incident Commander
ISA	Impact Summary
IPR	Intellectual Property Right
JDM	Joint Decision Model
MAV	Micro Aerial Vehicles
MODIS	Moderate Resolution Imaging Spectroradiometer
M-OODA	Modular - Observe, Orient, Decide, Act
MS	Medical Service
MTT	Minimum Travel Time
NRT	Near Real-Time
OS	Operating System
PE	Plan Execution
PF	Plan Formation
POI	Points of Interest
RBAC	Role-based-access-control
REST	Representational State Transfer
ROI	Region of Interest
ROS	Rate of Spread
SA	Situation Assessment
SAW	Situation Awareness
SMS	Short Message Service
SP	Service Platform
UI	User Interface
USAR	Urban Search and Rescue
VHR	Very High Resolution
VOST	European Virtual Operations Support Team
XMPP	Extensible Messaging and Presence Protocol

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Executive Summary

This deliverable presents the HEIMDALL service concept relevant actors and the possible use cases. In order to define the overall service approach (service portfolio), individual “products” and “services” to be provided have been identified in order to describe the HEIMDALL’s service value chain. The end-to-end service value chain example is illustrated with a forest fire scenario, but since HEIMDALL is a multi-hazard system, it can also be used for other hazard scenarios.

The main task contributing to this deliverable is T2.4 - Service Concept Specification and System Architecture and is a major part of Milestone 1 of HEIMDALL – the Service Concept and Architecture Definition.

By analysing the end users’ decision making process, we derived the system functionalities in close cooperation with them and defined the overall service approach of the HEIMDALL platform. For these functionalities the core components forming the HEIMDALL system have been identified and individual products and services to be provided are described pointing out the benefits they offer to end-users. The identified functionalities are: simulation and integration of different data sources, situation assessment, scenario matching, decision support and communication and information sharing among different actors and authorities.

Service packages that can be offered to address several business aspects and provide higher added value by combining the identified products and services are shown. The outcome of the document, and especially the identified service packages, are taken into account for the technical development of the HEIMDALL modules and the whole system. It will be further used as basis for the business plan developed in WP7.

1 Introduction

Many actors and disciplines are involved when it comes to the management of disaster situations and their cascading effects: from the police regulating the traffic to medical services treating casualties or fire fighters engaging the disaster. Further, national borders do not apply to natural and man-made disaster situations where for example forest fires can burn areas in adjacent countries.

Dealing with disasters begins before the disaster happens: Identifying hazards and building preparedness, considering options, building scenarios and training. HEIMDALL can efficiently support the training for those scenarios and allow collaboration between the actors and at the same time offers the possibility to include tools supporting the actors in their job.

In order to design the HEIMDALL system, the decision making process of actors in disaster situations has been analyzed with the idea of providing IT functionality to support their steps in finding a decision, and subsequent management of the disaster situation. For this, the HEIMDALL Consortium has been directly in contact with end-users, from different organizations, from different disciplines and from different EU countries, who provided us with descriptions of their processes. End-users from the medical services, fire and rescue services, command and control centers, civil protection and police departments are participating in HEIMDALL. A generalized process and reference workflow has been derived and several possibilities for our system to support the actors have been identified, everything in close interaction with the end-users.

Normative decision making models have been adopted in the guidance and training for emergency services. In these models, it is assumed that decision makers assess the current situation, formulate plans, and then execute the plans. Normative models of decision making typically identify three key phases: situation assessment (SA), plan formulation (PF), and plan execution (PE) [1].

The following normative models are used by the HEIMDALL end user partner organizations:

- Joint Decision Model (JDM) and the Decision Control Process (DCP) [1].
- M-OODA (Modular - Observe, Orient, Decide, Act) Model [2].

The JDM and DCP models have been introduced to the project by the Scottish Fire and Rescue Service (SFRS) whereas M-OODA reflects decision making performed by Red Cross in Italy (CRI). In addition to these normative models, the Catalan Fire and Rescue Service (INT-FRS) provided us with an illustration of their internal decision process which strongly resembles the DCP model.

The JDM model identifies phases of activities whereas the DCP and INT-FRS models perceive the resulting products as major pillars of the model. The M-OODA model adds focus on a cyclic behaviour/feedback loop. In the generalized model which is shown in Section 3, we tried to combine the activity-centric view of the JDM model with the cyclic behaviour of the M-OODA model and the product-centric view of the DCP and INT-FRS models for two major purposes: (a) identification of tools supporting the different activities with the possibility of repetitive usage at any time and (b) identification of information products and flows which need to be supported by means of suitable information management, exchange tools and communication mechanisms. The generalized decision making model and the functionalities which will be considered in the design are identified and presented: simulation tools and different data sources for information gathering, situation assessment, scenario matching, decision support and communication and information sharing among different actors and authorities.

In particular, the document is organised as follows:

- Section 2 specifies the use cases, roles and actors of the system.

- Section 3 describes the overall system approach including an example for the end-to-end service chain
- Section 4 presents the services and product of the HEIMDALL system
- Section 5 identifies services packages that could be provided with the HEIMDALL system
- Finally, section 6 summarizes and concludes the document.

2 Use Cases, Roles and Actors

2.1 Use Cases

HEIMDALL can be basically used during every step of the disaster management cycle but its main focus is on the preparedness phase and the actual response. It is a system for response planning and scenario building including simulation tools, scenario matching and situation assessment for performing what-if analysis. It is highly scalable and will include a wide range of data sources and the option to add users own data to build incident response plans. Decision support functionality helps during the response phase, while communication and information sharing systems help to interlink different authorities and ensures efficient communication within the own authority. Thereby, HEIMDALL will be usable in two modes:

- Preparation mode: in this mode the system offers everything to plan and train for emergencies. A database of historical data can be used, while lessons learnt and scenarios can be shared with other authorities to extend the data set.
- Response mode: the data of the actual situation is used in this mode. Nevertheless, the scenario database still can be used for comparing the current situation with historical or hypothetical ones. Pre-configured response plans and lessons learnt can also help during the emergency if they are similar to the actual situation.

The user will know at every step in which mode he/she is currently working. In this way, we guarantee that responsive features, for example the public alerting, are not used during exercises and planning to prevent unwanted consequences.

Although HEIMDALL is a multi-hazard platform, during the project the focus is on three main types of incident:

- Fire
- Flood
- Landslides

In-Situ sensors and simulation tools are tailored to these hazards while new sensors and simulation approaches can be developed and integrated. Risk and impact assessment, decision support methods and products and services are developed for these specific purposes and enable end users to perform a what-if analysis for the projection of potential impacts on people, property, environment and society. Due to the modular approach of HEIMDALL the system can in future be extended for other natural and man-made hazard types. In addition to single-hazard considerations, HEIMDALL supports assessment of hazard interactions during disaster preparation and response which may amplify the risk. Natural hazards triggering other natural hazards are taken into account as well as increased-probability relationships and networks of hazard interactions (cascades). HEIMDALL aims at providing information on estimated potential hazards being triggered by a hazard and on potential cascading effects which may lead to other hazards, considering the following hazard interactions but not limited to:

- A flood triggering a landslide
- A landslide blocking rivers and increasing the probability of floods
- A forest fire damaging a dam increasing probability of floods
- A landslide damaging high-voltage power lines increasing the probability of wild fires

HEIMDALL follows a modular approach based on web services enabling it to offer its products also as a service via web. This means that end-users can decide whether they prefer to buy hardware that they store in their premises or to rent access to the system via the web. Combinations for different modules are also possible: a user could decide for basic functionality for fire, with hardware running the fire simulator, in-situ sensors and SA tools,

while access to the flood features could be rented as service when required. This feature offers another use case: cooperation. HEIMDALL can be used for information sharing and communication. Since the concept is based on web services, it can be used by a single authority, e.g. fire fighters use the system for their disaster management, but it can also be used in case of multiple authorities, e.g. the fire fighters share their situation data with a medical service and the other way around completing the operational picture of every involved actor. For this, HEIMDALL separates itself in local units (LO) which are connected in a content based, federated architecture which ensures efficient data discovery and exchange. HEIMDALL will be based as much as possible on open standards and will offer mapping functionalities to further interlink multiple authorities of different countries and disciplines. Mapping, here, means that the provided information will be mapped to standard formats where possible. This can be especially important in cross-border scenarios where actors with different legal and operational frameworks must cooperate to efficiently respond to disasters. HEIMDALL is thereby secured with state of the art authentication and authorisation methods.

2.2 Roles and Actors

HEIMDALL is designed for multiple users and different use cases to support disaster managers, first responders, the public and basically everyone involved in disaster situations. An interdisciplinary team of Fire and Rescue Service (FRS), Police, Medical Services (MS), Civil Protection (CP) and Command and Control Centre (C&C) are participating in the HEIMDALL project to ensure an outcome that is tailored to the specific requirements of each authority and for all of them combined. In order to identify possible actors of the system, the following definitions for actors and roles are used [3]:

- An actor specifies a role played by a user or any other system that interacts with the system under consideration.
- A role defines the actions allowed to be performed to the system under consideration (e.g., access, read/write privileges, etc.). Each system user (an actor) should be assigned to at least one role.

In the following tables (Table 2-1 to Table 2-5), for each discipline the possible actors have been identified from the end-user perspective considering the different disciplines, pointing out the benefit that the system brings to their job.

Another actor that benefits from the system is the general public. First, with enhanced response capabilities of disaster, crisis managers and first responders (FR) the damage caused by a disaster can be decreased, i.e. less lives affected and less damage caused to property. Second, the public itself will benefit from HEIMDALL's features for public awareness, as, if the public has good information about the situation, and is effectively controlled by disaster managers, it is likely that a better resolution to the whole situation will be realised.

Table 2-1: Roles and benefits FRS

Role	**Benefits and Interest**
First responder (on field)	Real-time information about: • Risk awareness to improve care and safety • Significative inputs to evaluate the goals achieved of the incident action plan and tactical objectives
Incident commander (on field)	Real-time information about: • Decision making scenario • Potential evolution of the event • Hazards, goods and people affected • Effectiveness of the strategy applied

	• Action plan progress (tactical level)
Crisis manager (in the command and control centre of the incident)	Real-time overall picture of the incident for: • Objectives achieved • Strategic level supervision • Registration of the actions carried out • Sharing information with other agencies Tool to allow an easy cooperation and useful coordination protocols between other agencies
Communications officer	To have reliable and certain information to share with politicians and media press.

Table 2-2: Roles and benefits Police

Role	**Benefits and Interest**
First responder (on field)	Real-time information about: • Risk awareness to improve care and safety • Significative inputs to evaluate the goals achieved of the incident action plan and tactical objectives
Incident commander (on field)	Real-time information about: • Decision making scenario • Potential evolution of rthe event • Hazards, goods and people affected • Effectiveness of the strategy applied • Action plan progress (tactical level)
Crisis manager (in the command and control centre of the incident)	Real-time overall picture of the incident for: • Objectives achieved • Strategic level supervision • Registration of the actions carried out • Sharing information with other agencies Tool to allow an easy cooperation and useful coordination protocols between other agencies
Communications officer	To have reliable and certain information to share with politicians and media press.

Table 2-3: Roles and benefits MS

Role	**Benefits and Interest**
Incident commander or coordinator	The possibility to have, on the field, a full picture of the ongoing tactical situation and the potential evolution of the disaster are elements of great advantage for tactical decision making. Having a system able to provide new strategies or plan of actions is also an added value, giving to the Incident Commander (IC) the possibility to evaluate options elaborated on similar past situations.
Emergency manager or crisis manager/emergency delegate/operations	The possibility to have an overall picture with both ongoing operations and the development of the disaster (evolution of the hazards, risk analysis, etc.) help the global strategy and decision making at strategic level.

centre	It helps strategic or operational decision making and also the possibility to exchange information with other organisations involved in the same emergency.
Communications officer, fund-raising team	Providing the whole picture with reliable information about the incident – who is doing what, when, where, why, how – and the potential evolution of the event – who will be affected, how much … - can be a huge support to the communications and fund-raising teams.
First responder	Better and more rapid decision making will support the effectiveness of first responder's action, especially if they have to deploy special teams (e.g. Urban Search and Rescue (USAR)) or Advanced Medical Posts and other field structures. Responders will also have a rapid access to their tasks and their duties with no need to go-and-talk to somebody, reducing time to reach their beneficiaries and provide care
Administration and finance	The possibility to review the timing of all the actions related to the situation at that precise moment is very fundamental and useful to support both a post-emergency analysis and in case an investigation is ongoing.

Table 2-4: Roles and benefits CP

Role	**Benefits and Interest**
Crisis manager	A real-time overview of the incident ("situation picture") and the decision about activating- of the predefined crisis level and managing the incident by using the activated Crisis Management Unit (CMU) with a fixed organisational setting that includes well-known and tried procedures and activities.
Crisis Information & communication tasks, communications officer	Providing a real-time overview of the incident which contains reliable information about it - in a concise format such as: What has happened, where, when and why?; How is the media reporting on the situation (considered for long term)?; Risk Assessment – in relation to predefined scenario (e.g. Are there indications that the situation can get worse? What are the consequences on people, property, environment, and society´s critical functions? etc.) Information management – externally and internally.
Coordination of activities and resources	A real-time overview of the incident – based on the situational picture which includes: • Actions – who has done/is expected to do what, where, when, and how? • Resource-use – which resources are applied where, which resources are still available, and which resources do we need to solve the incident?
Incident commander	A real-time overview of the incident and management of the incident including decisions about the tactical and technical side of the intervention of a very wide-ranging nature. Calling for assistance from another municipality's rescue preparedness, state rescue service or a private rescue service if deemed necessary - due to the nature and extent of the incident. Providing the real information in the way to support the real-time overview of the incident.
First responder	A real-time overview of the incident and the immediate response to the incident with the available resources – based on the incident commander´s decisions about – which primary and secondary tasks

	must be tacked?
Administration of information	Administration of information is a task concerning activation of the CMU and the information management that, as a minimum, should be evident from the activation call (time and place for the first meeting, participants, agenda, initial data about the incident, situation pictures, log-book, e-mails, SMSs, maps etc.).

Table 2-5: Roles and benefits C&C

Role	**Benefits and Interest**
Incident commander	A real time overview of the incident and the consequences of implementing various intervention options. An overview of the critical infrastructure and the identification of priorities based upon vulnerability information.
Sector commander	A real time overview of the incident and feedback on the impact of the chosen tactics for resolving the incident. An improved appreciation and knowledge of the location of assets and priority areas.
Command and control	A real time overview of the incident and the location of all resources. An overview of the critical infrastructure and identification of priorities based upon vulnerability information.
First responder	A real time overview of the incident and the immediate priorities.
Training coordinator	The ability to use data and scenarios from live incidents and simulations of incidents to provide realistic training events for commanders.
Resilience manager	The ability to use forecast data combined with historic evidence to prepare for and mitigate the impact of natural hazard events. This may include moving resources, placing mitigation (flood defence/fire breaks) or warning and informing citizens.

3 Overall Service Concept

HEIMDALL is a modular system, thus following a modular service approach. This means that every module on its own can provide a product or series of products and its services can be used and requested on its own. However, with the use of the Service Platform (SP) the modules are integrated and are able to build on one another and offer additional features in responding to disasters and preparing for them. These functionalities can also be booked in several service packages described in Section 5 or of course with all modules integrated forming the complete HEIMDALL system. The main benefit provided by the system is that it can be easily extended. If a customer wants to access new functionalities at a later moment, they can be integrated just like external systems that are possibly already in use by the customer.

Throughout the project the following definitions of product and service will be used:

- Product: “it is a good, idea, method, information, object or service created as a result of a process and serves a need or satisfies a want.” [4].
- Service: “it is a valuable action, deed or effort performed to satisfy a need to fulfil a demand.” [5].

For instance, products would be data items which can be obtained or accessed through the system such as satellite images or maps. A service could be allowing the transmission of information to first responders on the field (while the information to be transmitted would be a product).

In order to identify potential products and services, we analysed how end-users make their decisions and identified the outcomes of the different steps. The results are illustrated in Figure 3-1: the cornered boxes show the steps of the JDM followed by rectangular boxes with the outcome of the step. For instance, the outcome of the “gather information & intelligence” step is a situation or a simulation whereas after the “identify options and contingencies” step a plan or a decision results.

The three phases of the normative models situation assessment (SA), plan formulation (PF) and plan execution (PE) are shown in the background of the modified JDM model. The SA phase corresponds to the gathering of information step and includes the assessment of risk. The development of the working strategy is an interaction of the SA and PF, while the PF persist until a decision is taken. PF is followed by the PE which corresponds to taking and the coordination of the action, i.e. the execution of the decision. To close the cycle, information on the outcome of the action is gathered and consequently the SA starts again.

In each of these steps HEIMDALL functionalities can support decision makers and incident commanders during disasters, for preparation and in the aftermath. These functionalities are presented in the outer circle in Figure 3-1 indicating with the size of the arcs which are the supported steps. In the following, a brief example of how HEIMDALL can support during a disaster situation, more details on all products, services and how each HEIMDALL functionality support end users are presented in Section 4.

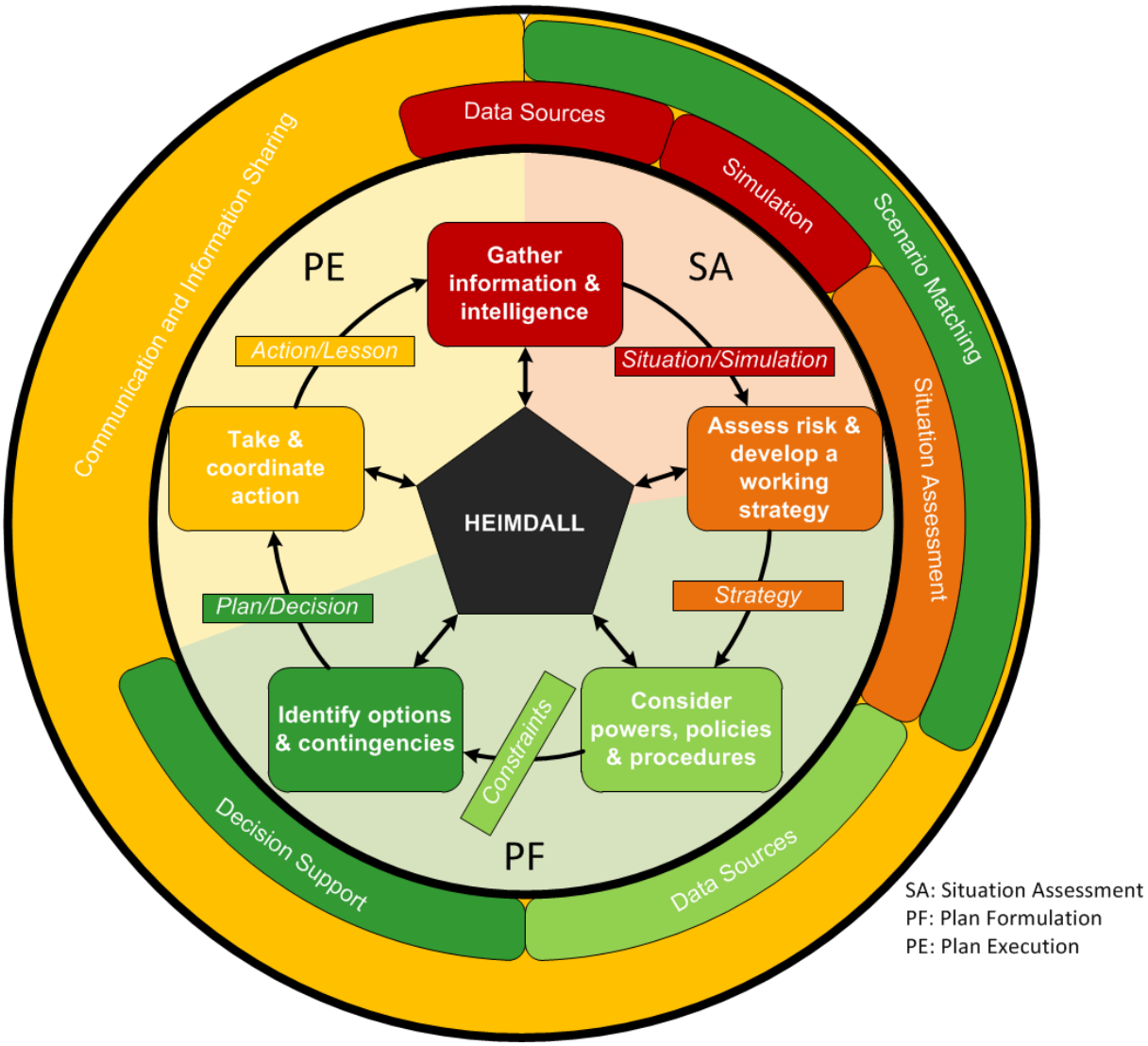

Figure 3-1: Decision Making Model and HEIMDALL functionality

Let's assume a forest fire situation where the fire is reported by a citizen or detected by in-situ sensors. We are already in the gathering of information and intelligence step. HEIMDALL data sources, like Satellite Earth Observation (EO) or various in-situ sensors help to get a clear picture of the situation and share this picture among all actors; colour of the smoke, are there visible flames. Fire fighters arriving at the scene can use the HEIMDALL app to upload their information directly to the platform making it immediately available to the Command and Control Centre (C&C). HEIMDALL will also include several interfaces to external systems, e.g. weather data providers, thereby, following the modular approach inherited from the PHAROS project [6]. With this it is extendable, i.e. systems that are in use by authorities can be integrated. HEIMDALL simulation tools can be used to create a forecast of the fire behaviour so that an even better situational picture is gained.

As the next step in the JDM model, the risk assessment is carried out, and a working strategy is developed. For this the Situation Assessment functionality of HEIDMALL can be used where scenarios and mitigating action can be confirmed using the simulation tools and conducting what-if-analysis. For instance, fire breaks can be drawn and their effect simulated. Furthermore, an impact assessment can be done to determine the effect on critical infrastructure. With the scenario matching functionality, users can find similar situations in a database and look for the mitigations taken, and their outcomes, to evaluate his/her strategy. This can also be used in the previous step, since the real situation data can also be used to check for similar situations and identify if an existing response plan might be available from a similar scenario. Incident commanders are provided with the maximum

amount of information which is presented in a clear way, enabling them to assess the risk and decide what strategy will be used to fight the fire. Most features in HEIMDALL are customizable, so if the incident commander prefers to view only a specific set of data for a dedicated incident, they can save this in his/her settings which helps him/her to always have their preferred view of the available information.

The incident commander will then consider what procedures/polices and powers exist: procedures for fighting the type of fire involved, do we have the authority to evacuate buildings if necessary, etc. Here, HEIMDALL data sources are the perfect choice. In the system database policies and procedures can be saved and checked. Similar information sources that are already in use by authorities can be integrated as additional information source. The communication functionalities ensure that policies and resources can be communicated with other authorities and within their own organization.

Before the action is taken, the next step is to consider what contingencies are needed and what options exist: if the fire escalates, what is required? if casualties are recovered, is there somewhere to take them? etc. HEIMDALL offers decision support functionalities for this. Optional locations for forward command posts (FCP) are shown or possible target areas for evacuation. The system is also scalable and can be extended in the future to further adapt to possible evolution of users' requirements.

The final step is to take action. This is where the HEIMDALL communication and information sharing systems are key features to communicate decisions. The cycle then starts again by monitoring if the actions achieve what was planned; if new information is discovered such as changing weather conditions, the HEIMDALL system incorporates this information for the next iteration of the cycle.

After the disaster situation, those involved have to use lessons learned to help plan and prepare for the next event. During the incident all data can be stored in a standardised situation report that can be used to evaluate the disaster management and identify lessons learnt in the aftermath of a crisis. These can then be attached to the situation report. A whole database of situation reports forms the best basis for the scenario matching and for response planning where again, the simulation tools and the SA functionality, with its what-if-analysis, can be used for response plan creation.

3.1 User Interface

Within HEIMDALL a web based Graphical User Interface (GUI) will be implemented enabling end users to access the products and services. The choice of a web based solution primarily provides the system with wider flexibility and access to most users with an internet access and scalability to adopt extra features and/or requirements and devices.

The accessibility to various types of products and services through the GUI will be determined by specifying profiles within each organisation, which dictate the user's access rights, as described in the next section. The GUI will also provide the relevant tools to access the various components of the system, such as Simulation tools, Earth Observation data, Decision Support, etc. Furthermore, the GUI will contain a set of dedicated views that will group and orchestrate the different functionalities and services that HEIMDALL is aiming to build. Access to a mapping tool enables users to determine the location of different events or critical infrastructure close to an incident, which can be used for response planning, lessons learnt and incident response. Another objective of this GUI will be to offer end users an improved situational awareness of events as well as providing them with mechanisms to support the decision making phase during an incident.

Table 3-1: Outputs and formats User Interface (UI)

Product	**Short description**	**Format**
Display of information in	Information illustrated in the GUI shall include map layers, sensor data, simulation/assessment	The format of each corresponding product.

the GUI	results, decision information products, etc.	
Provisioning of products and services to users	A web service for on-demand retrieval of the system products	Product format

3.2 User and role management

Within HEIMDALL various services will be developed for the management of the various users and roles. These services will provide access control supporting features authorisation and authentication. In this way, controlled disclosure of information to authorised entities will be facilitated. In the cases where it is needed, state of the art data encryption mechanisms will be deployed for the stored data. Concerning the traffic in the HEIMDALL network (though VPN connections) this will be always encrypted on an end-to-end basis using state-of-the-art encryption techniques, so that potential eavesdroppers cannot intercept and decode the exchanged information. Apart from encryption, VPN security mechanisms assure authentication of both peers (to prevent man-in-the-middle attacks) as well as data integrity (to prevent alteration of exchanged data by a malicious entity).

Role-based-access-control (RBAC) will be used for HEIMDALL, which is a policy neutral access control mechanism defined around roles and privileges. The components of RBAC, such as role-permissions, user-role and role-role relationships make it simple to perform user assignments. Within HEIMDALL the RBAC approach will be used to facilitate administration of security for the users and their permissions.

A role-based security model means that each user will have one or more assigned roles determining what the person is allowed to see, what they are allowed to modify, and what they are allowed to execute. For example, when those roles are applied at the document level, it means that, for a given role, either you can see this document or you cannot see it. The roles presented in section 2.2 will be in the selection of roles but in principle the system is not limited in this regard.

The user and role management component allows the configuration and monitoring of the various service platform (SP) services as well as of the SP as a whole. The SP is the central integration unit of HEIMDALL; its technical details can be found in in D2.12. The SP Management component consists of both a centralised service (for managing platform-wide parameters) as well as a distributed management service for each of the aforementioned SP components. SP management procedures allow, among others:

- Configuration of access rights
- Configuration of interfaces
- Creation/ modification/ update of data repository
- Overview of data repository contents and basic visualisation
- Security settings for the various exposed interfaces

Interaction with the administrator will be facilitated by a graphical web-based interface.

For the implementation of the user and role management service, state of the art and open source solutions, such as Keycloak [7] will be considered.

More details on the design of the HEIMDALL user and role management shall be provided in D4.4 and D4.5 Users and Roles Management Specification (draft and final versions due in M20 and M38, respectively), whereas they will be implemented in D4.6 Users and Roles Management Services in M38.

Table 3-2: Outputs and formats Role Management

Product	**Short description**	**Format**

Authentication	Allows a user or an application/service to access the system based on the credentials provided (specifying access rights/privileges to resources). Only users with valid credentials will be allowed access to the system.	Comply with the HEIMDALL password policy (to be described in D4.4) Token format
Access control	To apply selective restriction to HEIMDALL resources (services/products and actions on them). Valid users will have access to the resources based on their role and access rights.	Web interface/UI
Admin console	Through the admin console, administrators can centrally manage all aspects of the user management server. • Enable and disable various features. • Create and manage applications and services, and define fine-grained authorization policies. • Create and manage user accounts, including permissions and sessions.	Web interface/UI
Account management console	Through the account management console, users can manage their own accounts. • Update the profile, change passwords. • Manage sessions as well as view history for the account.	Web interface/UI
User profile	This is the user profile which shall hold their preferences, e.g.: • Default UI language • Default map layers • Default areas of interest • Default active role This is used by the access control component.	JSON

4 Products/Services

In the following the various HEIMDALL products and services are presented in detail showing how they support end users during the decision making process and how they help them to respond to and prepare for disasters. The sections are organised according to the identified service functionality following the overall service concept presented in section 3 so that the sections can be related to the JDM.

4.1 Data Sources

Within HEIMDALL various data sources will be exploited in order to provide the necessary information to the user and inputs to the HEIMDALL services. Therefore, the simulation, scenario matching and situation assessment services generate the products for the practitioners, supporting the mitigation, preparedness, response and recovery, i.e. all phases in the disaster management cycle. The data sources are key assets for the information gathering step of JDM, since they are basically the senses of a digital system and extend the eyes and ears of a user having control over this system. They are also HEIMDALL's solution for the consideration of power, policies and procedures: in the databases all necessary information can be stored and accessed.

4.1.1 General Data Management Products and Services

A set of general data management services shall be developed and offered by the HEIMDALL SP in order to facilitate the exchange of information between the various services as well as information sharing between local units of the system (see D2.12 – HEIMDALL System Architecture). This approach provides flexibility at different levels: on one hand, different services can be available in each local unit and made accessible to users accessing other local units by means of publishing them in the products and services catalogue (more details are provided in D2.12). On the other hand, additional external services can be easily added to the overall architecture by publishing the corresponding services or information in the catalogue and establishing the corresponding connection, without additional integration efforts.

Whenever new data is introduced or updated in the system an alert notification can inform the end user about this. In this way it is ensured that the user does not miss important events. The user can configure the data sources, events or thresholds for this notification preventing him from losing track because of too much information. The full list of products provided in context of the general data management can be seen in Table 4-1.

Table 4-1: Outputs and formats general data management

Product	Short description	Format
Georeferenced data storage service	An OGC compliant server allowing users to view and edit geospatial data.	OGC WMS/WFS/WCS
GIS database	A database that allows the storage of spatial and geographic information and execution of location-based information retrieval.	REST API/JSON
"Plain" data storage service	A web service allowing the storage and retrieval of generic data and/or documents to the corresponding database(s).	REST/JSON
"Plain" database	A database that allows the storage and retrieval of plain data information.	Document and/or NoSQL storage
Historic data service	Provide access to historic data (past incidents)	JSON (comply with scenario format)

Workflow invocation service	Interconnect services in order to implement the workflows, triggered in an automated fashion or manually	REST/JSON
SP Monitoring	Basic monitoring metrics regarding SP operation, through log files, etc.	REST/file/JSON
Interfaces with various services	Provide interfaces with various HEIMDALL and external services for instance: • UI • EO data • Sensor data • External weather, hydrological, etc. data sources and services • Scenario management • Modelling and simulation • Risk and vulnerability assessment • Situation assessment • Decision support • Information gateway • etc.	Acquire data (either raw or processed) not provided by the currently installed data sources or tools. Communicate sensor data, events and simulation results and retrieve decisions/ recommendations.

4.1.2 **Earth Observation**

Within HEIMDALL several reliable and high-quality products based on multi-sensorial Earth Observation (EO) data will be generated and provided to the user to support disaster management activities in the context of the natural disasters flooding, fires, and landslides. This includes the following products: flood masks, burn scars, fire hot spots, masks showing the extent of abrupt landslides as well as information about the velocities of slow-moving landslide events. The products are derived from adequate optical and radar satellite sensors such as TerraSAR-X [8], Sentinel-1/2 [9], MODIS [10] and VHR optical satellite missions. The products will be provided as vector and raster files and will be derived by the following semi-automatic and automatic services:

- Automatic Sentinel-1 [11] and TerraSAR-X [12] flood processing chains
- Automatic Sentinel-2 burn scar mapping chain
- Automatic MODIS-based hotspot service for wildfire detection [6]
- Automatic Sentinel-2 flood processing chain [13]
- VHR optical flood processing chain [13]
- Sentinel-2 landslide mapping chain [13]
- Processing chain for updating landslide activity based on Sentinel-1 interferometric data

The provided EO based products, with a short description and their formats are presented in Table 4-2.

Table 4-2: Outputs and formats EO

Product	**Short description**	**Format**
Flood extent	Flood binary mask (with permanent water areas excluded)	GeoTIFF and ESRI Shapefile
Burn scar	Burnt areas binary mask (extent)	GeoTIFF and ESRI Shapefile
Fire hot spots	Thermal anomaly locations enhanced with meta data (administrative units, affected landcover	ESRI Shapefile

	class)	
Landslide extent	Binary mask of abrupt landslide affected areas	GeoTIFF and ESRI Shapefile
Information about landslides	Velocity of slow-moving landslides	ESRI Shapefile

4.1.3 **Aerial Based Data**

In HEIMDALL, we will make use of aerial based data for forest fire in-situ monitoring and surveillance. To this end, we devise a system composed of two main parts:

- A swarm of cooperative micro aerial vehicles (MAVs) equipped with thermal cameras
- A portable control station (tablet) that allows the user to interact with the system through a GUI. In particular, it allows the user to define a region of interest (ROI) and a set of points of interest (POIs).

The swarm is autonomously patrolling the ROI and monitors the area for fire hot spots. If a drone detects a potential hot spot its sends a geo-referenced alert signal to the swarm controller. Furthermore, the swarm can be used for gathering geo-referenced thermal and visual pictures for each of the POIs defined by the system and an on-demand video stream broadcasted by a drone selected by the user through the GUI. The list of products coming from aerial based data are listed in Table 4-3

Table 4-3: Outputs and formats aerial based data

Product	**Short description**	**Format**
Geo-referenced alert signal	If a MAV of the swarm detects a potential hot spot an alert signal is send to the user for notification	JSON
Pictures	Pictures taken by a MAV to monitor the actual situation	JPEG
Thermal Pictures	Thermal pictures taken by a MAV to monitor the actual situation and identify fire behavior.	JPEG
On-demand video stream	Each MAV equipped with a camera can be selected from the control station and a video stream of the area below the MAV can be streamed.	MPEG

4.1.4 **Landslide monitors**

In order to detect the deformation of unstable areas HEIMDALL includes tools for landslide monitoring. All services will be performed at single slope level (local scale) using geotechnical/hydrogeological in situ sensors and images collected from Ground Based Synthetic Aperture Radar (GB-SAR) installed on site, and geodesic/topographic instruments that will be used in occasional campaigns.

First services delivered will be the **processing and interpretation of radar data** to provide three/dimensional deformation maps of the slope and temporal series for measurement points. Two use cases are considered for the radar monitoring system:

- In cases with a rapid evolution and a high risk, a continuous monitoring to update the risk level will be provided. The device can then be installed permanently in front of the instable slope and the information is updated almost in real time.

- If the monitored slope has lower risk for landslides the device can be installed just for a predefined time to collect data for simulation.

Second service is the **monitoring of the critical slopes and their surroundings using geotechnical/hydrological sensors**. This service will be continuous from the moment of the installation of the sensors on.

Third service will be the **performance of geodesic or topographic campaigns** in order to obtain detailed information on the terrain geometry. With the repeatability of this campaigns, it will be possible to detect changes precisely.

Last service will be the **reporting of quantitative and qualitative information** about terrain movement in critical slopes. This service will include information collected from previous services, as well as from other sources, such as civil and operative reports or UAV data. The products provided are summarised in Table 4-4.

Table 4-4: Outputs and formats landslide monitoring

Product	Short description	Format
Terrestrial radar for landslide monitoring	Post processed data from terrestrial radar and interpreted maps and plots classified by a deformation scale.	Georeferenced shape files or 1D Plots (e.g. excel files).
Geotechnical/hydrological sensors data for landslide monitoring	Data collected by sensors installed in the moving areas or their surroundings. The goal of these sensors is to provide information on the magnitude of terrain movement or parameters that affect terrain stability, such as soil pore water pressure or rainfall.	Database
Geodesic or topographic surveys	Representation of geometric features of the terrain surface based on models of Earth, and approximated according to the survey accuracy.	Raster/Vectorial files.
Near real-time terrain movement information	Report including all the data available related to movement at monitored sites. This product includes: terrestrial radar and geotechnical/hydrological sensors data, geodesic or topographic surveys and other civil and operative reports.	Report

4.1.5 **Crowdsourced and First Responders Data**

Nowadays, crowdsourced and first responders' data are becoming very relevant during the response action. They provide control centres with an inside awareness of the situation that would otherwise be very tough to describe or imagine. With the benefits of feeding the HEIMDALL system with this kind of input in mind, a citizen and first responder's mobile application will be implemented. These mobile applications will provide the following features:

- Authentication
- Alerts receiver
- Hazard
- Incident
- First responders' location
- Chat

In order to support as many devices and, consequently users as possible, an Android application will be implemented during the project. Likewise, it is envisaged to develop an iOS application with the same features in the long term. Similarly, within each platform, these applications will be developed with the most representative versions of their operative systems (OS). More specifically, the minimum version required will be:

- Android 2.3 – Gingerbread
- iOS 9

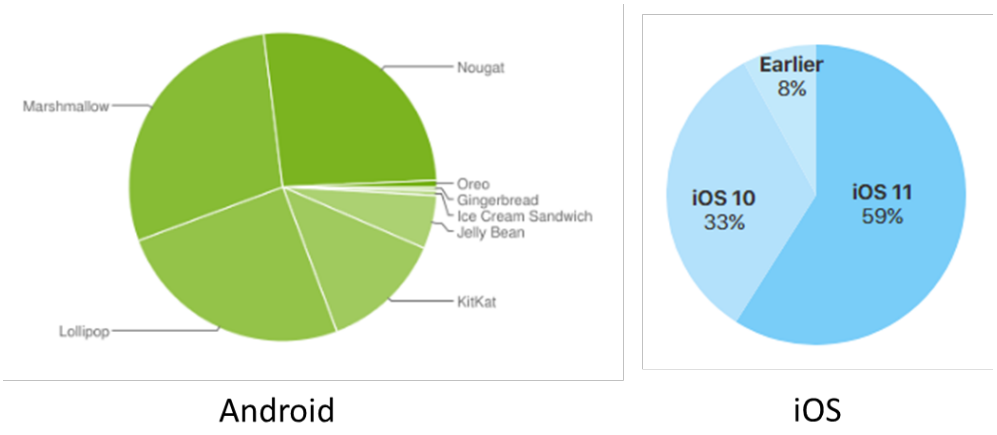

Figure 4-1: Mobile platform versions distribution [14], [15]

These applications will be available in both Google Play and App Store, to broaden the spectrum of end users. Consequently, making the applications available to the wide public through the stores brings some security challenges - for instance, personal data leaks. In order to solve these security issues, the communication between the mobile applications and the server side will be done through HTTPS requests, ensuring a secure channel of information exchange. Due to the growing population awareness of mobile telecommunication issues like identity fraud, personal data leaks, continuous location tracking, et al., both Android and iOS stores are now forcing developers to provide a detailed application privacy description where it must contain how end users' data are managed and stored by the application and system.

From a first responders' perspective, the data that the system will be capable to access will be:

- Real-time geolocation of whereabouts of all first responders. This will help to broaden the visibility of the resources in the field to the emergency coordinator, improving resource management and resource safety during an emergency. In order to fully provide this service, the user must grant the application to access the latest user's location.
- Reception and aggregation of real time images that will increase the situational awareness picture of the incident. Similarly with the previous service, the user must grant permission to the application to access to the camera.
- Direct communication from the first responders towards both control centre and other first responders on site. This capability will be delivered through a chat feature.

On the other hand, the data exchange between the system and the crowdsourced mobile application capabilities will be the following:

- Reception and aggregation of real time images from a new and/or ongoing incident. Having this capability available to the general public allows the system to be alerted of new possible emergencies and also, get different unusual angles of visibility that the first responders will not be able to get access to.

- User's profile metadata exchange when either an incident is reported or an image is sent to the system. This user's metadata exchange will require the user's acceptance before any information is sent. By doing so, the application will notify and clarify to the user of what data is about to be sent, giving the flexibility to the user to take a final decision.
- Alerting mechanism that will notify to the population of any new incidents happening in their surroundings and, it will also propagate any update or progress related to a particular event.

Table 4-5 depicts the data exchange that both first responder's application and crowdsourced application will be performing against the HEIMDALL system, in order to support the features described above.

Table 4-5: Outputs and formats crowdsourced and FR data

Product	**Short description**	**Format**
Authentication	Only first responders with HEIMDALL credentials will be able to access the FR mobile application services.	Object represented by e.g. JSON
Alerts receiver	Reception of alerts/information messages sent from the HEIMDALL platform to alert, update and notify of incidents to both citizens and first responders.	Probably Common Alerting Protocol (CAP) format TBA
Hazard	Potential physical event observed by citizens	Object represented by e.g. JSON
Incident	Observed physical event by first responder. Information updates sent from first responders in the fields.	Object represented by e.g. JSON
First responders' location	Continuous tracking of first responders location during an incident - providing a wider awareness of where exactly each individual is.	Object represented by e.g. JSON
Chat	A simple XMPP (Extensible Messaging and Presence Protocol) client that enables the first responders to exchange information with other first responders as well as with the command and control centres.	XMPP (Extensible Messaging and Presence Protocol)

4.1.6 **External Systems**

Apart from the data provided by the HEIMDALL subsystems, we foresee that the developed workflows will also involve externally available information and services by third party providers, such as e.g. weather data. For this purpose, the HEIMDALL Service Platform will implement service-specific interfaces as plug-ins, which will retrieve the information from the external service provider using the service provider's API, adapt it and feed it to the Service Platform via the already provided open interfaces.

The HEIMDALL-generated information will need to be communicated to external services, including external users and social media platforms. For this purpose, controlled access to OGC interfaces for direct data acquisition will be possible, complying with the security and access policies of HEIMDALL. In addition, the service gateway functionality will be possible via an Enterprise Service Bus (ESB) where external services will be able to subscribe to data/events and retrieve them via a variety of interfaces (e.g., HTTP, REST, SOAP, FTP, e-mail, etc.).

More details on the SP interfaces to HEIMDALL subsystems as well as external services, including specific technical interface specifications and message formats and examples will be provided in D4.1 Service Platform Design and Specifications (on M18) and their final version in D4.2 on M38.

The external data sources to be considered will be the following but are not limited to:

- Copernicus Emergency Management Service (EMS)
    - Copernicus EMS mapping. Products are Rapid Mapping, Risk, and Recovery [16].
    - European Flood Awareness System (EFAS) [17]
    - European Forest Fire Information System (EFFIS)[18]
- Copernicus Climate Change Service
- Copernicus Atmosphere Monitoring Service
- Copernicus Land Monitoring Service
- Copernicus Marine Environment Monitoring Service
- Global Disaster Alert and Coordination System (GDACS) [19]
- Meteorological data and weather forecasting services
- Hydrological information
- Cartographic data and services
- Census data (population density, etc.)
- Critical infrastructure information
- Resource management systems
- Data from 112 systems
- Data from the VOST community (European Virtual Operations Support Team) [20].

Data provided by citizens through the HEIMDALL application (crowdsourcing information)

More details on the HEIMDALL interfaces to external systems and services, including specific technical interface specifications, will be provided in D5.9 and D5.10 Interfaces for External and Existing Systems (draft and final versions on M22 and M38 respectively), whereas these interfaces will be implemented in D5.11 on M38. A full list of the provided products on context of external systems can be found in Table 4-6 and the ones for external interfaces in Table 4-7, respectively.

Table 4-6: Outputs and formats external systems

Product	**Short description**	**Format**
Service-specific interfaces as plug-ins	Interfacing services that will implement the communication with external systems and adapt their output to the Service Platform's internal open interfaces.	
Enterprise Service Bus	ESB hosts the various services and interface proxies to external systems. It enables the use of HTTP/REST, FTP and other protocols for accessing the external interface services and products.	XML, JSON, binary data (videos, photos, documents etc.)

Table 4-7: External interfaces considered for HEIMDALL

Product	Short description	Format
Copernicus Emergency Management Service	Copernicus Emergency Management Service (Copernicus EMS) provides information for emergency response in relation to different types of disasters, including meteorological hazards, geophysical hazards, deliberate and accidental man-made disasters and other humanitarian disasters as well as prevention, preparedness, response and recovery activities.	Reference, delineation and gradient maps (including pre- and post-disaster) in raster, vector and KMZ files through HTTP.
Copernicus Climate Change Service	The Copernicus Climate Change Service (C3S) will provide deliver seasonal forecasts and climate predictions by holding records on temperatures, rainfall and drought, sea levels and ice sheets.	NetCDF files through FTP and Web API services.
Copernicus Atmosphere Monitoring Service	The Copernicus Atmosphere Monitoring Service (CAMS) provides enhanced atmospheric environmental information available as analyses, re-analysis and forecasts at global and pan-European scales.	GRIB and NetCDF file format through FTP or Web API services.
Copernicus Land Monitoring Service	The Copernicus land monitoring service provides geographical information on land cover/land use and on variables related to vegetation state and the water cycle.	Raster files through HTTP or Web API services.
Copernicus Marine and Environment Monitoring Service	The Copernicus Marine and Environment Monitoring Service (CMEMS) provides near real time products, multi-year products, in-situ observations and forecasts.	NetCDF file through HTTP or FTP protocols (python scripting supported).
GDACS information	"GDACS is a cooperation framework under the United Nations umbrella. It includes disaster managers and disaster information systems worldwide and aims at filling the information and coordination gap in the first phase after major disasters. GDACS provides real-time access to web-based disaster information systems and related coordination tools."	Various • API/Web services including WMS • KML file with the latest alerts and polygons of interest
Meteorological and hydrological information	Weather and hydrological parameters (wind, wind direction, temperature, relative humidity, precipitation, etc.) Forecast over 3, 6, 9, 12, 24, 36, 48h	REST/JSON or XML files
Cartographic data	Various layers including for example, geography, bathymetry, administrative, etc. grids.	Shapefiles, GeoTIFF
Census data	Population density of the areas of interest.	WPS.REST services and/or shapefiles, GeoTIFF
Critical infrastructure information	Assets that are essential for the functioning of a society and economy [21], [22].	Shapefiles, GeoTIFF

4.2 Simulation Services

Within HEIMDALL different simulation tools will be developed and integrated to provide products and services for the different multi-hazard case studies. These simulation services and products have as main aim previewing the extent and the potential behaviour of the hazards with the aim of, on the one hand, providing the end-users with information about the hazard to ease decision-making and on the other hand using the information of some of the created outputs as inputs to other components of the HEIMDALL system. The forecasts can be done with the actual situation information, collected by HEIMDALL data sources, or with (hypothetical) inputs manually introduced by the user which supports scenario analyses and response planning. They bring a benefit for the development of a working strategy since what-if analyses are enabled (further explained in Section 4.3). If the actual situation information is used the simulation services are a tool to support the "gathering of information" step since it can be used to get a better picture. The hazards that are addressed within the project are forest fires, landslides and floods, but thanks to the modularity of the system other simulation tools can be easily integrated within the system in the future allowing the multi-hazard capabilities of HEIMDALL to be extended.

4.2.1 **Fire Simulation**

The forest fire simulation tool provides products and services related to the forecast of forest fire behaviour and susceptibility. These products aim at supporting the end-users in obtaining information about the hazard extent and conditions to allow enhanced decision making, scenario building and response planning. The products and services provided by the forest fire simulation tool include:

- Forecast of forest fire behaviour in space and time. This service will create a set of outputs related to the extent of the forest fire as well as to the conditions and behaviour of the fire during its progression. These outputs will be created as vector or raster files that will be graphically represented through the GUI. The main end-user target roles (see Section 2.2) for the related products include:
    - First responder (on field)
    - Incident commander (on field)
    - Crisis manager (in the command and control centre of the incident)
- Forecast of the impact relevance of a forest fire on vulnerable assets. This service will aim at estimating the relevance of the impact of a forest fire for a given area or areas. The susceptibility will be calculated according to the number of affected people and/or environmental economic losses. Furthermore, it will provide the estimation of the paths that the fire may take towards the vulnerable areas. These outputs will be created as vector or raster files that shall be graphically represented through the GUI with the aim of supporting the end-user in knowing which areas are more vulnerable to the fire. The main end-user target roles for the related products include:
    - Incident commander (on field)
    - Crisis manager (in the command and control centre of the incident)
- Calculation of the set of critical points and elements in the terrain that affect drastically the way the fire behaves. This service shall calculate/identify for a given area the geological elements of the terrain that influence the way the fire behaves, i.e. the elements that may accelerate the progression of fire or that have the opposite effect. This output will be represented graphically through the GUI and shall support the end-users during planning as well operational tasks by knowing at which points of the terrain the fire can have a given behaviour. The main end-user target roles for the related products include:
    - Incident commander (on field)

- Crisis manager (in the command and control centre of the incident)

The previously mentioned simulation services will receive inputs from External Systems such as weather data (see Section 4.1.6), interactions from the user through the User Interface (see Section 3.1) and provide some outputs as inputs to the Situation Assessment and the User Interface to display the results (see Sections 4.3 and 3.1).

The products planned to be provided for forecasting the forest fire behaviour in space and time will be the following (further presented in Table 4-8):

- The time the fire is estimated to arrive for each cell of the simulation which represents at which time in hours the fire burned a given spot of the terrain. This raster product will be represented through a coloured scale that represents the number of hours and that goes from “0” to “n”.
- Estimated fire perimeter represented through isochrones. This vector output is related to the previous product and represents each hour of the fire arrival time ranging from “1” to “n” through graphical isochrones.
- Main fire paths the fire is expected to take, showing the fire cells that are most active in the fire. This raster output represents the points in the terrain where the fire is estimated to be most active providing the end-user with the information of the critical cells of the fire that are contributing to the fire spread.
- Flame length for each cell of the simulation. This raster output provides the expected flame length for each point of the simulation perimeter and simulation area.
- Fire intensity for each cell of the simulation. This raster product provides the intensity (in kW/m) of the fire for each point of the simulation perimeter and simulated area.
- Rate of Spread (ROS) of the fire which provides the speed of the fire for each cell of the simulation. Raster product that represents the speed (in m/s) of the fire in each cell of the simulation perimeter and simulation area.
- Out of suppression capacity areas. Raster output that provides the areas inside the simulation perimeter and simulation area that surpass the suppression capacity of the responders. A cell presents out of suppression capacity when the fireline intensity, flame length or ROS surpass certain values. These values shall be configurable by the end-users.

A forecast of the potential impact of a forest fire on vulnerable assets/areas will be provided including:

- Main paths a fire will take towards vulnerable areas and/or assets. This raster product provides the estimation of which are the paths of the fire that will cause the most impact in certain areas according to the number of affected population and/or environmental economic losses.
- Relevance of the impact the fire will have on these elements/areas (e.g. based on number of affected population). This raster product represents the estimation of the relevance of the impact of a forest fire for a given area or areas. The susceptibility shall be calculated according to the number of affected population and/or environmental economic losses.

A calculation of a set of critical points and elements will be done in the terrain that affect the way the fire behaves which will include:

- Critical elements of the terrain that affect the behaviour of the forest fire. This (vector or raster) product provides the geological elements in the terrain that influence the way the fire behaves, i.e. the elements that may accelerate the fire progression or elements that have the opposite effect. The elements to be identified are the following:

- Mountain ridges: The mountain crests affect the direction as well as the speed of a forest fire.
- Consolidation lines: Identification of slope lines that complies with the following rules: i) Separates two fuel types; ii) area with high slope; iii) The most dangerous vegetation fuel is located in the highest zone.
- Valley nodes: The union of two or more secondary rivers/streams in a main river occurring in areas with a high slope.
- Vertical walls: Natural firebreaks that blocks the progression of a fire.

This service shall calculate/identify for a given area the geological elements of the terrain that influence the way the fire behaves, i.e. the elements that may accelerate the progression of fire or that have the opposite effect. This output will be represented graphically through the GUI and shall support the end-users during planning as well operational tasks by knowing at which points of the terrain the fire can have a given behaviour.

Table 4-8: Outputs and formats Fire Simulation

Product	**Short description**	**Format**
Time of arrival	Time the fire is estimated to arrive for each cell of the simulation. Calculated inside the simulation perimeter and in the area of simulation (AoS).	Raster in GeoTIFF format. Ranges from “low” to “high” where low=”0” and high=”n”.
Fire perimeter	Represents the arrival time of the fire through isochrones, each line represents an hour of fire spread. Calculated inside the simulation perimeter.	Vectorial output. In GML or GeoJSON (TBD)
Minimum Travel Time (MTT) fire paths	Main paths taken by the fire. It shows the fire cells that are estimated to be most active in the fire. Calculated inside the simulation perimeter.	Raster in GeoTIFF format. Represented in percentage and ranges from “0” to “1”.
Flame length	Expected height of the flames in meters. Calculated inside the simulation perimeter and in the AoS.	Raster in GeoTIFF format. Ranges from “low” to “very high”. The several outputs levels are: • Low = <1.5m • Moderate= 1.5m – 2.5m • High= 2.5m – 3.5m • Very high= >3.5m
Fire intensity	Represents the fire intensity in kW/m according to the existing fuels of the burned area. Calculated inside the simulation perimeter and in the AoS.	Raster in GeoTIFF format. Ranges from “low” to “very high”. The several outputs levels are: • Low = <346 kW/m • Moderate = 346 – 1.730 kW/m • High= 1.730 – 3.460 kW/m • Very high= >3.460 kW/m
Rate of Spread	Provides the speed of the fire for each cell of the	Raster output of the ROS of the fire in m/s and in GeoTIFF

(ROS)	simulation. Calculated inside the simulation perimeter and in the AoS.	format. This output ranges from “low” to “extreme”. The several outputs levels are: • Low = < 0.028 m/s • Moderate = 0.028 - 0.17 m/s • High = 0.17 – 0.56 m/s • Very high = 0.56 – 1.39 m/s • Extreme = >1.39 m/s
Out of suppression capacity	Represents the areas inside the simulation perimeter that surpass the suppression capacity of the fire. A cell presents out of suppression capacity when the fireline intensity, flame length or ROS surpass certain values. By default, these values are defined as 99.4m/s for the ROS, 9.8m for the flame length and for the fireline intensity 51960.9 kW/m. Calculated inside the simulation perimeter and in the area of simulation (AoS).	Raster output in GeoTIFF
Mountain ridges	The mountain crests affect the evolution of a fire.	Raster or vectorial output
Consolidation lines	Identification of slope lines that comply with the following rules: • Separates two fuel types • Area with slope. • The most dangerous fuel is located in the highest zone	Raster or vectorial output
Valley nodes	The union of two or more secondary rivers/streams in a main river occurring in areas with a high slope.	Raster or vectorial output
Vertical walls	Natural firebreaks that block or slow down the progression of a fire	Raster or vectorial output
Impact oriented fire paths	Main paths a fire is expected to take towards vulnerable areas.	Raster in GeoTIFF format. Represented in percentage and ranges from “0” to “1”.
Forest fire impact relevance assessment	Relevance of the impact the fire will have on vulnerable areas	Vector or raster map of qualitative classes (low – medium – high).

4.2.2 **Flood Simulation**

The flood modelling service will provide simulated flooding scenarios in terms of extension and flood dynamic information, according to different flood return periods and flood types. The simulation tool provides the following outputs:

- Flood hazard map scenarios of water extension at regional scale at coarse spatial resolution (30 meters) produced using hydrological modelling and a simplified hydraulic approach;

- Flood hazard map scenarios of water depth at regional scale at coarse spatial resolution (30 meters) produced using hydrological modelling and a simplified hydraulic approach;
- Flood hazard map scenarios of maximum extension at high spatial resolution (2-5 meters) on some selected areas produced using a complete 2D hydraulic model;
- Flood hazard map scenarios of water depth at high spatial resolution (2-5 meters) on some selected areas produced using a complete 2D hydraulic model;
- Flood hazard map scenarios of water velocity at high spatial resolution (2-5 meters) on some selected areas produced using a complete 2D hydraulic model;
- Tool for dynamic mapping of flood water depth using hydrological modelling and a simplified hydraulic approach; the tool can be interactively activated by the operator using different precipitation scenarios (e.g. forecasted by meteorologist) and considering local mitigation actions (e.g. sandbags or mobile gates displacements).

Furthermore, the flood tools will enable the following services:

- Identification of the hazard scenario for areas simulated with high spatial resolution
- Real time hazard mapping using a simplified hydraulic approach

The products offered by the flood simulation and their formats are presented in Table 4-9.

Table 4-9: Outputs and formats Flood Simulation

Product	**Short description**	**Format**
Real-time flood extensions (Simplified model)	Maps of flood maximum extensions at regional scale at coarse spatial resolution (30 meters)	Raster of binary values (flooded/not-flooded) in GeoTIFF format
Real-time water depth (Simplified model)	Maps of maximum water depth in the flooded areas at regional scale at coarse spatial resolution (30 meters)	Raster of real values of water depth in GeoTIFF format
Flood extensions (Complete model)	Maps of flood maximum extensions selected from pre-computed database at high spatial resolution (2-5 meters)	Raster of binary values (flooded/not-flooded) in GeoTIFF format
Water depth (Complete model)	Maps of water depth in the flooded areas selected from pre-computed database at high spatial resolution (2-5 meters)	Raster of real values of water depth in GeoTIFF format
Water velocity (Complete model)	Maps of water velocity in the flooded areas selected from pre-computed database at high spatial resolution (2-5 meters)	Raster of real values of water velocity in GeoTIFF format
Dynamic mapping tool (hydrological model and simplified hydraulic)	Interactive tool activated by the operator that produce dynamic maps using hydrological modelling and a simplified hydraulic model based on different scenarios and considering local mitigation actions	Raster of real values of water velocity in GeoTIFF format

4.2.3 **Landslides**

The system will be equipped with landslides simulation services with the aim of providing information related to terrain movements: its occurrence susceptibility, movement changes and thresholds for triggering factors.

Landslide simulation **services** will be a tool for the Situation Assessment (Figure 3-1). These services have been divided into two main groups. The first group of services include the **assessment** and **evaluation** of parameters, necessary to provide the second group of

services. These parameters are: **terrain movement susceptibility**, **thresholds for triggering conditions** and **potential landslide warning**. All these services are based on input data gathered by the system from internal and external sources. Internal sources are basic static information (such as digital elevation models of the terrain and lithology classes) and dynamic data from in-situ sensors and EO observation (e.g. landslide inventories). External sources are essentially meteorological parameters. These services are intended to provide information to end users, especially before the triggering of an incident.

The second group of services includes the updates related to the first group of services. These services consist on **updates** on **terrain movement susceptibility**, **detection of terrain movement changes** and **terrain movement warning**. These services are thought for both end-users and first responders in the field, who will use this information to assess risk and develop the working strategy.

Products derived from landslides simulation services are listed in Table 4-10. First product is the **terrain movement susceptibility map** which is determined through a model based on the terrain movement inventory and topographic, geological and soil characteristics information (adaptable to soil information availability). Second product is the **dataset of triggering conditions thresholds** for terrain movements. Third product will combine two previous products to provide **scenarios of potential landslide warning areas** based on susceptibility map and triggering conditions evolution. Finally, the processing of Sentinel-1 data will provide the **Sentinel-1 terrain movement map**, used to detect terrain movements.

Table 4-10: Outputs and formats Landslides simulation

Product	Short description	Format
Terrain Movement Susceptibility map	Provides the Susceptibility of the terrain to landslide failure within a selected area, grouped in polygons. This product is derived from the susceptibility modelling, and it is updated according changes in inventory map.	Raster or vectorial output
Dataset of triggering conditions that can trigger terrain movements	Provides information on the amounts of rainfall which can trigger terrain movements.	Database
Scenarios of potential landslide warning areas based on triggering conditions evolution.	Based on the Terrain Movement Susceptibility map, it provides the probability of landslide occurrence over time (depending on terrain movement information and triggering conditions).	Raster or vectorial output
Sentinel-1 terrain movement map	Provides magnitude of terrain movement following the satellite Line Of Sight (LOS) direction in the areas of periodic monitoring.	Raster or vectorial output or report

4.3 Situation Assessment

The HEIMDALL Situation Assessment (SA) process will generate composite and meaningful information for the user to maintain, sound and complete situation awareness (SAW) as a basis for effective plan formation and decision making prior to and during an incident. Core element for this is a scenario: in this case, a digital representation (JSON object) of all related information that has been collected, for instance: internal and external data sources, simulation results, risk and impact assessment information, decisions made, actions taken and lessons learnt. If desired, the system will connect all incoming information to a given incident in form of a scenario object which acts as information pool for effective SA. This core element can also be used to create situation reports by taking snapshots of the current sensor data and available information. Situation reports can be generated for analysis, reporting and archiving purposes or for sharing them with partners. Based on a sequence of

scenario snapshots (situation reports) end users are able to retrace the scenario evolution. In general the HEIMDALL project aims at supporting decision makers in building and sharing of multidisciplinary scenarios. In particular, scenarios are used as an input or output by the following HEIMDALL tools:

- Data Sources feed scenarios with hazard and incident information and conditions
- Simulation Services project the extent and the potential behaviour of the hazard which defines a scenario
- Situation Assessment is performed by the use of scenarios
- Scenario Matching compares available scenarios with input parameters
- Decision Support provides goal-oriented information for scenarios
- Data Sharing and Communication provides means for transforming scenario information into a situation report and sharing them accordingly

As a major pillar, scenarios shall be modelled to represent both – real situations and simulated scenarios. A scenario is defined during the project as a real or hypothetical situation comprised of a potential hazard or incident, projected or produced impacts and all related disaster management decisions, plans, and lessons learnt.

The end user of the system has full control of scenarios (objects) being able to create, store, retrieve, edit and delete scenarios and connect response plans throughout their decision making process and will be able to access all information associated to a scenario in order to explore them in detail. It will be possible to copy scenarios which will ease the process to further create hypothetical scenarios, e.g. in order to derive a simulated scenario from a real situation.

In terms of JDM, the functionality will build on top of the previous steps by using the gathered information and processing it with the user's help for the development of a working strategy and for risk impact assessment. The SA functionality will include some more advanced features that support in this phase and can be seen as own modules.

First, potential risks and impacts which the hazard might impose on people, property, society and environment can be assessed. This step is often referred to as Impact Assessment (IA).

Products generated during the first step can be combined in a second module with simulation results and user-generated information in order to gain a descriptive impact summary. This summary includes location-specific risk information, aggregated risk numbers such as total number of affected people and estimated potential cascading effects.

These functionalities lead to the possibility to perform a scenario analysis or a what-if analysis which is a service that HEIMDALL can be used for. Parameters of simulations can be manually defined to investigate about the possible outcome of alternative scenarios, like "what happens if the wind direction changes" or "what happens if a fire break is put in a different location", and so on. These simulated scenarios can be compared with the actual situation or with historic scenarios in order to identify the best response plan for the given situation. This feature is completed by the possibility to further connect it with the scenario matching tool (described in 4.4), where similar scenarios can be found and used for the comparison and as basis or to find interesting parameters for what-if analyses.

The following sections describe services and products for IA and the impact summary in more detail, the SA specific ones are presented in

Table 4-11 in detail.

Table 4-11: Outputs and formats Situation Assessment

Product	**Short description**	**Format**
Scenario	Scenario object describing a hazard (or	Descriptive format e.g.

	incident) conditions and referring to all associated information such as decisions and countermeasures taken, lessons learnt incident information, etc. This includes multi-hazard scenarios, including the description of interacting and cascading effects between incidents provided by the Situation Assessment component for that scenario. Different temporal snapshots of a scenario are distinguished by revision number.	JSON
Situation Report	Snapshot of a scenario containing the parameters of the current situation.	In standardized, XML-based message format such as EDXL-CAP or EDXL-SitRep
Decision	Decision taken by emergency service roles in charge, i.e. C&C, I.C. associated to a scenario. Decision description and rating (negative or positive)	Descriptive object represented by e.g. JSON; drawing, georeferenced format for formalizing paths of decisions
Response Plan	Sets of documents as defined in D3.1 [24]	Descriptive object represented by e.g. JSON
Measure	Countermeasure or prevention measure taken during a scenario such as sandbag location and height, fire break, etc. with appropriate parameters useful as an input to simulation associated to a scenario.	Georeferenced object, e.g. GeoJSON
Lesson learnt	Lesson learnt associated to a scenario.	Descriptive object represented by e.g. JSON

4.3.1 **Risk and Impact Assessment Products and Workflows**

Hazard, exposure and vulnerability products will be developed for the different multi-hazard case studies. These products, functions and user-oriented workflows will be integrated into software components which will serve as a basis for the generation of Impact Summary Information (ISA information) in a next step. The provided crisis information and methods for risk analysis, emergency response and scenario building will include:

- A Multi-Hazard Risk data set considering the exposure, vulnerability to the respective hazards as well as possible cascading effects on hazards. The multi-hazard risk product will be the basis for the situation assessment (SA) process as illustrated in Figure 3-1. The user will be supported by this information in their strategy formation. For the risk assessment of multiple hazards, information on the respective hazard intensities and magnitudes has to be provided by either simulation (Chapter 4.2 and Figure 3-1) or observation services (Chapter 4.1.2, 4.1.3 and Figure 3-1).
- A Physical Exposure data set containing the quantity and location of transportation networks, critical infrastructures, residential and commercial building stock. The physical exposure data set is one key input for the risk assessment process included in the situation assessment (SA) process as illustrated in Figure 3-1. The user will be supported by the exposure information during his working strategy development. To generate the information on exposed physical elements hazard information has to be

provided by either simulation (Chapter 4.2 and Figure 3-1) or observation services (Chapter 4.1.2, 4.1.3 and Figure 3-1). Detailed information on the critical infrastructure components has to be provided by the respective national authorities.

- A Human Exposure data set containing the population exposed to a hazard on building or building block level. Daytime and night-time data sets will be provided. Similar to the physical exposure data set, the human exposure product is a key input for the risk assessment process included in the situation assessment (SA) process as illustrated in Figure 3-1. The user will be supported during working strategy development and Plan Formation (PF) in general through the information on quantity and location of affected population. To generate the information on exposed population, hazard information has to be provided by either simulation (Chapter 4.2 and Figure 3-1) or observation services (Chapter 4.1.2, 4.1.3 and Figure 3-1).
- Quantitative estimate of the physical impact with respect to hazard. The physical impact will be expressed as damage taken (%) or expected reconstruction costs (€). Quantitative impact assessment supports the user in the Plan Formation process as illustrated in Figure 3-1, including Situation Assessment and Decision Support with quantitative information on the expected damage on elements in the physical exposure data set. For high quality quantitative impact assessment quality of the input data has to be sufficient: The hazard information (e.g. flood event) generated by either simulation (Chapter 4.2 and Figure 3-1) or observation services (Chapter 4.1.2, 4.1.3 and Figure 3-1) has to fulfil a minimum level of detail (e.g. at least provide the extent and the flood depth) in order to apply accurate damage functions.
- Human impact product providing an estimate of coping and adaptive capacity of the affected population. Similar to the quantitative information on the expected damage on elements in the physical exposure data set, the potential human impact supports the user in the Plan Formation process with qualitative information on the degree of the population's ability to cope with or adapt to hazard stress. This information will be generated using census information and statistical data. The level of detail depends on input data quality (census information, statistics).

The provided products are also summarized in Table 4-12 including their formatting. The targeted end user roles (see chapter 2.2) for the products include: (I) First Responder (on field), (II) Incident Commander (on field) and (III) Crisis Manager (in the command and control centre of the incident). Besides the before mentioned products the risk and impact assessment will provide the following services:

- Preparation of high detail physical exposure datasets containing information on buildings or building block level based on analysis of Digital Elevation Model (DEM), multispectral image data, VGI data and simulated or observed hazard products.
- Human exposure estimation by means of population disaggregation using disaggregation methods, census data, the physical exposure data set and building usage information. With the function information of buildings day- and night-time population will be calculated through asymmetric mapping approach.
- Analysis of physical vulnerability (buildings, transportation network, environment) in respect to the hazards forest fire, flood and landslide using state of the art vulnerability functions (e.g. HAZUS [26], CAPRA [27]). The calculated vulnerability will be expressed as a function linking hazard intensity to percentage damage. These functions can then be used to obtain a degree of damage measured in percentage (expressing the physical impact) connected to a specific scenario.
- Analysis of the human vulnerability using a generic social vulnerability index based on demographic attributes, socio-economic status and access to public resources that express the degree of coping and adaptive capacity of the population.
- Integration of Near Real-Time (NRT) optical and radar EO data products.

- Elaboration of event extent or monitoring mapping databases specifically for scenarios or from previous events (Copernicus EMS, International Charter, etc.).
- Classification of exposed elements at risk (buildings, critical infrastructure, and population) based on multi-sensor EO data using a standard taxonomy.
- Semantic information extraction from crowdsourced data and sensor data.

The creation of the Risk and Vulnerability Assessment products follows workflows which can be triggered by the user through the user interface or automatically through predefined rules (e.g. new simulation result or hazard extent available). The following workflows will be considered:

- Physical exposure assessment workflow: Process to trigger/run the related internal processes and create the human exposure outputs.
- Human exposure assessment workflow: Process to trigger/run the related internal processes and estimate the physical exposure.
- Physical impact assessment workflow: Process to trigger/run the related internal processes and estimate the physical impact. The physical impact assessment will be obtained through the overlapping of the hazard information with the exposure and vulnerability information.
- Human impact assessment workflow: Process to trigger/run the related internal processes and estimate the human impact. The physical impact assessment will be obtained through the overlapping of the hazard information with the exposure and vulnerability information.

Table 4-12: Outputs and formats Risk and Impact Assessment Products and Workflows

Product	**Short description**	**Format**
Multi-hazard risk	Calculation of multi-hazard risk product based on the defined Physical and Human Impact products and Physical and Human Exposure products including possible cascading effects on hazards.	Raster or vector map of qualitative classes (low – medium – high)
Human Impact Assessment	Qualitative assignment of social vulnerability based on demographic attributes, socio-economic status and access to public resources.	Raster or vector map of qualitative classes (low – medium – high)
Human Exposure	Estimation of exposed population based on disaggregation of census data population (sources) on exposed buildings or building blocks (targets).	Raster or vector density map
Physical Exposure	Estimation of elements at risk, consisting of transportation networks, critical infrastructures, residential and commercial building stock. The building stock information will be used during the human exposure estimation.	Vector map (e.g. store building height, building function, etc.)
Physical Impact Assessment	Quantitative estimation of the expected damage on elements at risk in regard to a specific observed/simulated hazard through the use of specific vulnerability libraries. Physical vulnerability functions will be assigned based on the characterization of exposed elements (e.g. building age, building material or building height) according to a predefined taxonomy. Hazard events will be considered	Vector map of percentage damage for building stock and transport networks; Raster map of affected for population.

	through their intensity, expressed as water depth and/or velocity for floods and linear intensity for forest fires.	

4.3.2 Impact Summary

The impact summary module will serve as an integrator of multiple pieces and layers of information provided by the different HEIMDALL data sources and external data services, scenario management, models and simulations, risk and impact assessment products, and user criteria and generates descriptive Impact Summary Information (ISA information).

Multiple pieces and layers of information provided as input HEIMDALL data sources will be integrated and aggregated into groups based on time, space, constraints and resource management strategies. For example, all available information items for the situation are filtered and grouped based on their relation to the most significant infrastructure locations. In general, strategies set the highest priority on saving lives followed by saving property and rounding off with securing the environment. Furthermore, intervention usually starts at the local level. However, as organizations and individuals act under varying policies, constraints and roles the definition of groups must be customizable.

In a second step, grouped information is interrelated to each other and to prior knowledge such as expert criteria, geospatial base data, and pre-defined geographical locations of interest (GOIs) in order to generate ISA information for the different identified groups. For example, impact summary information for a hospital in the vicinity of a disaster location would include the risk level, the estimated time of arrival (ETA), the evacuation time.

Table 4-13: Outputs and formats Impact Summary

Product	**Short description**	**Format**
GOIs at risk	Hazard and conditions are intersected using expert criteria with pre-selected geographic locations of interest (GOIs with ranking provided by user), simulation results and risk vulnerability information: List of relevant critical/significant infrastructure at risk (e.g. blocked transportation systems such as roads and bridges, potentially affected C&C sites, etc.) For each GOI: Risk index Optional: ETA (minimum if aggregated) if provided by simulation Evacuation time (minimum if aggregated) if provided by simulation In addition, based on reports and observations: Damage assessment information (maximum if aggregated)	Descriptive format; georeferenced objects where applicable, e.g. in GeoJSON format
People at risk	Estimated number of people at risk	JSON Object
Potential cascading effects/ hazards	Estimated potential hazards being triggered by the hazard and potential cascading effects (e.g. dam at risk, river at risk, high-voltage power line at risk) which may lead to other hazards (based on pre-defined interacting hazards in case	JSON Object

	studies)	
Hazard evolution information	Combination of new information with already existing knowledge available through previous scenario snapshots: Situation changes (e.g. “Flame length/water depth has increased", Fire/water velocity has increased", "Fire front has moved", “weather situation has changed”, etc.)	JSON Object

4.4 Scenario Matching

The HEIMDALL project aims at supporting decision makers by the provision of capabilities for the comparison of a situation with historic and simulated scenarios, their evolution, performed response activities and lessons learnt. Information on similar scenarios and associated information such as mitigation and decisions having been taken in these scenarios help decision makers to identify possible actions suitable to the situation at hand and to project the outcome of actions and mitigations when applied. The scenario matching, on the one hand, can be used for information gathering if the parameters of an actual ongoing incident are used for searching similar scenarios and, on the other hand, for the development of a working strategy and risk impact by checking response plans of similar scenarios. Consequently, similar scenarios identified by the Scenario Matching functionality contain information on decisions and prevention and mitigation measures taken, their positive or negative evaluation, and lessons learnt. The product provided by the Scenario matching functionality is a slit of similar scenarios as can be seen in Table 4-14.

As a basis for multi-criteria pattern matching, analysis, and comparison of scenarios, suitable multi-hazard and risk-based comparison metrics will be identified and formalized. These metrics will build upon the determination of suitable distance factors and relations between scenarios in terms of time and space rule-based algorithms, geospatial analysis, and emergency response knowledge. Matching criteria and metrics are configurable and visible to the end users in order to foster matching process customization and optimization.

Table 4-14: Outputs and formats Scenario Matching

Product	**Short description**	**Format**
List of similar scenarios	List of similar scenarios including countermeasures resp. actions taken in these scenarios, sorted by distance Distance is a numerical value in order to quantify the difference of a scenario to input parameters	JSON Object

4.5 Decision Support

In the Plan Formation (PF) phase, the HEIMDALL tools will provide different goal-oriented information products that support the decision maker in identifying options and contingencies in the form of: Decision Support Information (DES information) also generated during the SA process. The purpose is to provide the decision maker with the best available information to decide on the path to follow to achieve the desired outcome. The DES information will include goals, e.g. move affected C&C to a safe site. Here, expert criteria for the identification and ranking of potential response infrastructure can be included by the user and will be considered by the system. Furthermore, the following services will be considered:

- The identification of affected goal-related infrastructure based on ISA information and expert criteria
- The determination of alternative goal-related infrastructure based on ISA information and expert criteria

An example for DES information is a list of potentially safe (potentially not affected for a given time) alternative forward command post sites which, when included in a situation report, can help the decision maker to meet the best possible contingencies in case that a forward command post need to be moved (see Table 4-15).

In order to reflect the internal diversity of end users in terms of different legal frameworks, national, regional and organizational strategies, roles and profiles, end users are able to customize infrastructure such as alternative forward command post sites which will be considered for the generation of DES information. In addition, decision makers can configure rules and thresholds and modify DES information according to their individual and organizational needs and knowledge.

Table 4-15: Outputs and formats Decision Support

Product	Short description	Format
Information about safe, significant infrastructure	Hazard and conditions are intersected using expert criteria with pre-selected locations of interest (optional), simulation results (optional) and vulnerability information: List of potentially safe infrastructure until time x (e.g. safe hospital, safe route until time x) based on simulation	Descriptive and georeferenced objects where applicable, e.g. in GeoJSON format
Information about safe response infrastructure	• Potential alternative C&C and forward command post sites • Potential firewater-reservoirs, sand pits for filling sand bags, materials storage, rescue equipment storage, etc.	Descriptive and georeferenced objects where applicable, e.g. in GeoJSON format

4.6 Data Sharing and Communication Services

Improving the cooperation capabilities among different authorities of a single country or in the European framework is one of the core requirements of the HEIMDALL system. For this, HEIMDALL provides services for communication and information sharing. Information and data can be shared within an organization as well as to other authorities using the HEIMDALL system while content oriented architecture increases the efficiency of data sharing. Users can grant access to data and always keep an overview of who can access which data. A data and service catalogue helps with the information discovery and the connection to other authorities. The system takes care to tailor the data so that every user can access it in his/her preferred or mandatory format. HEIMDALL makes use of common data formats, mostly based on open standards for this. Communication tools are also provided to every level so that C&Cs of an organization can stay in touch with its FR in the field or FCPs. Communication with C&Cs, FCPs and FR of other authorities even in other counties is provided. A messaging platform supports this rapid information exchange by either forwarding text messages or multimedia content.

All steps in the decision making model will be affected and supported by the communication services of HEIMDALL. For the “gathering information and intelligence” phase, it will be possible for first responders with the HEIMDALL smartphone application to use the messaging platform and send their position and pictures as well as all important information to wherever it is needed. This feature can also be provided to citizens in the long term. The assessment of risk and the development of a working strategy are supported by the exchange of risk data, lessons learnt and historical data of similar events. For the “consider powers, policies and procedures” step, communication tools are the foundation enabling this by communicating the resources and powers available and inform about the policies and procedures to implement. The same holds for “identifying of options and contingencies”, where HEIMDALL provides the basic features enabling this step. Taking and coordinating the action is impossible without communicating strategies, decisions, updates, information on the

situation etc. They need to be shared with other actors and form the basis for success in responding to a hazard. In order to guarantee always a good flow of communication an optimized version of the system is provided. In order to ensure that the relevant information is available in all locations, the system must be aware of the status of the communication links in order to prioritise the information to be transmitted in case of limited connectivity due to the use of narrowband channels. For communication, for example SMS will be an option to share information with responders in the field for very low channel quality. In case the communication infrastructure in the incident area is destroyed during the hazard, HEIMDALL provides a product to rapidly provide coverage (described in more detail in the next section). Since the information might be sensitive, private or confidential, it is possible to make use of state of the art link encryption and authorisation. Further, HEIMDALL offers a service for keeping the general public informed. This is done in the first instance with alerting means with multi-channel capabilities and automatic translation to inform tourists and all not native speaking people.

4.6.1 **Communication to Remote Areas**

Nature disasters like wildfires, landslides and floods can be located in remote areas and apart from big cities. It furthermore, can happen that the existing communication infrastructure is destroyed in during disaster. These facts bring some telecommunications challenges emergency response organisations, such as low quality connectivity coverage from standard mobile networks or sometimes even, no coverage at all. Taking this into account, it has been decided that an easy way to assure a continuous connection option, no matter where or what conditions, will be via satellite communications. Satellite communications can be provided through a rapidly deployable, lightweight and portable Ka-band satellite terminal that can be transported and installed at any site. Apart from the antenna, it will require the installation of a modem that will be responsible for generating a Wi-Fi network. Once the antenna and the modem are installed, any end user that is within the Wi-Fi network coverage area will be able to connect to the Internet.

Envisaging an interrupted communications service will benefit first responders by granting access to the information available on the platform, along with reporting back to the control centre and maintaining a continuous communication link among all personnel involved in the incident. Similarly, it will also benefit the usage and functionality of the first responders' mobile application, as its services are based on having an internet connection.

5 Service Packages

One of the core benefits of the use of HEIMDALL is to exploit the synergies existing between the different products and services forming end-to-end service chains with a higher added value. Therefore, to complete the service portfolio presented in this document, it is necessary to analyse the services which could be provided together as dedicated packages making use of their interconnections.

5.1 Data Service Package

This basic package allows the registered users to access the different products available in the system on a subscription basis. Users are allowed to select the relevant products from the ones available in the federated system and pay either according to the requested data or to the subscription mode. The details related to the provision of the package from a business point of view will be provided in D7.6 (draft) and D7.7 (final).

The products which the user can access include:

- Data acquired or processed by the modules available in the platform:
    - Data provided by the data sources described in Section 4.1 (which might be processed by the system)
    - Simulation results, as described in Section 4.2
    - Situation assessment products, as described in Section 4.3
    - Scenarios available in the scenario repository

It is important to highlight that the Data Service Package includes the access and download of the different products generated by any local unit connected to the federated architecture, but does not allow the user to request the generation of any additional product by triggering the available services. Users can be notified when a new relevant product is available, according to the user subscription. The possibility of users accessing the different available data will depend in the last term on the agreements previously performed between the data provider and the user organisation.

5.2 Emergency Management Package

These packages are designed to satisfy the needs of practitioners managing the emergency situation. The basic Emergency Management Package includes access to all data available in the system, under the conditions of the Data Service Package, the scenario management services and the data communication services, as described in Section 4.6. This way, users subscribed to the Basic Emergency Management Package will be provided with access to all available data and will be notified when new inputs that might require the generation of a new scenario are received. Finally, users can communicate decisions to the first responders in the field. The basic package can be extended with one or both of the following options:

5.2.1 **Situation Assessment:**

It allows users to use the simulation tools described in Section 4.2 on demand as well as accessing the situation assessment functionalities described in Section 4.3. This option provides users with additional tools to make a better decision to be communicated to the relevant stakeholders.

5.2.2 **Scenario Matching:**

It allows users to use the scenario matching functionalities described in Section 4.4 on demand, to support end users in the decision making process.

5.3 Planning Package

An authority booking this package can upload its own data into the system and use the system functionalities for response planning and lessons learnt. No information on the real situation can be accessed. As in the Emergency Management Package the situation assessment and the scenario matching module can be booked as extensions.

5.4 Communication Package

The communication package includes 3 modules of the HEIMDALL system: The information gateway, access to the catalogue and the equipment for the communication with the remote areas (satellite dish, modem, Access Point (AP) and corresponding satellite capacity). It is the perfect package to exchange information within the own and with other authorities as well as to keep the public informed and forward commands.

6 Conclusion

This document has presented the HEIMDALL service concept, including the HEIMDALL main use cases which show that it can be used:

- For all phases of the disaster management cycle, with special focus on preparedness and response;
- For multi-hazards with current focus on fire, flood and landslide;
- For single or multiple organization scenarios, later also in international context;
- Locally or as web service.

The concept has been developed in cooperation with end-users from different countries and disciplines, which namely were Fire and Rescue Service (FRS), Police, Medical Services (MS), Civil Protection (CP) and Command and Control Centres (C&C). They also provided a list of actors in their discipline that will benefit in their job from the use of HEIMDALL.

A generalized decision making model has been defined and used to identify opportunities to support end-users with dedicated system functionalities: simulation tools and different data sources for information gathering, situation assessment, scenario matching, decision support and communication and information sharing among different actors and authorities. For each of these functionalities, services and products which will be an outcome of the HEIMDALL project have been presented. As basic concept of HEIMDALL, a graphical user interface (GUI) to display data, control the system as well as the user and role management have been introduced. Therefore, HEIMDALL offers a very flexible approach where most settings are customizable. It has been described that the offered services and products could be offered on their own, however with the modular approach they can be combined to services packages which will include a:

- Data services package
- Emergency management package
- Planning package
- Communication package

These packages and the whole service concept will be further elaborated for the business plan preparation.

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