D2.2
System Engineering Report
Issue 2

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Document History			
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0.1	26/06/2018	Initial version from D2.1	DLR
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1.0.F	21/12/2018	Final version	DLR

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List of Acronyms

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
EC	European Commission
EMS	Emergency Management Service
EO	Earth Observation
EUW	End User Workshop
FR	First Responder
FRS	Fire and Rescue Service
FTP	File Transfer Protocol
GIS	Geographic information system
GOI	Geographical Location of Interest
GUI	Graphical User Interface
IG	Information Gateway
ISA	Impact Summary
LU	Local Unit
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
MS	Milestone
IMS	Internal Milestone
SatCom	Satellite Communication
SM	Stakeholder Manager
SP	Service Platform
TM	Technical Manager
UeRM	User Role Management

UI	User Interface
WP	Work Package

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Executive Summary

This deliverable documents the ongoing activities of HEIMDALL's Task 2.2 – System Engineering and Release Management, which started with the project beginning and will end in M42. The task focuses on two main objectives:

- To monitor the development activities (WP4, WP5 and WP6) in order to ensure interoperability of interfacing elements, consistency of mutual inputs/outputs, exploitation of mutual synergies between sub-systems and avoid parallel developments.
- To define and manage the different releases of the system in terms of requirements to be satisfied.

The state and progress of the HEIMDALL project is presented in terms of system engineering. The project has successfully closed release A and demonstration A, where the outcome is having a first version of the system available. At the moment, the design phase for the next release is ongoing taking into account the user feedback collected during demonstration A. Furthermore, the planned timing of the next deliverables and developments is shown and a state of the implementation is given.

This deliverable is the second issue out of five, presenting the status of the HEIMDALL technical work at M20. The follow up deliverables are due at M27, M34 and M40 and will present the progress made and the current state at that point in time.

1 Introduction

The HEIMDALL project is structured in seven work packages (WPs) which are interrelated as indicated in Figure 1-1. The planned activities are divided in four areas:

- Management
- Stakeholder engagement, demonstrations and societal impact
- System engineering
- Dissemination, standardisation and business plan.

As can be seen in the following figure, the project management surrounds all activities and forms the basis of the project. The two pillars of the project are the stakeholder engagement and the technical developments, including the technical WPs 4-6. WP 2 is their steering WP and interlinks them with the stakeholder WP in active interaction. This allows for incorporation of user requirements and feedback identified in WP 3 into the engineering scope by means of deriving system and technical requirements and accordingly coordinating them with the technical WPs. Both pillars contribute to WP 7 the dissemination, standardisation and business plan.

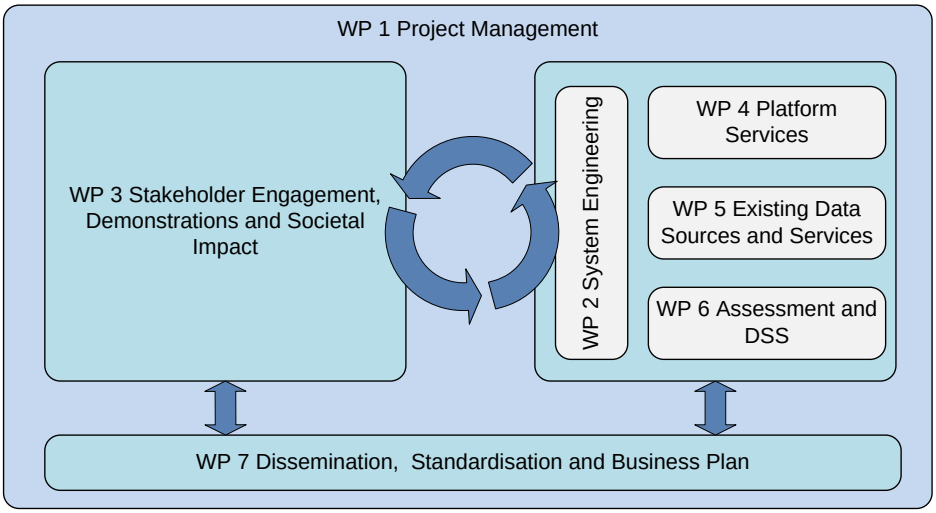

Figure 1-1: HEIMDALL project work package relation

This deliverable addresses the system engineering approach followed during the project and reports the status of the technical WPs at the moment of submitting this deliverable at M20. The document is organised as follows:

- Section 2 gives and update on the state of the project in terms of system engineering approach which is a consecutive Vee model.
- Section 3 describes the releases management and the planned requirements for the releases.
- In section 4 the current state and the progress of the implementation until the submission date of the deliverable is presented.
- Finally, section 5 summarizes and concludes the document.

2 System Engineering Status

As presented in D2.1 [1] the engineering approach of HEIMDALL follows the Vee model for systems engineering according to the INCOSE Systems Engineering Handbook [2], [3], shown in Figure 2-1. This Vee model is used in four consecutive system releases to incrementally develop the system and ensure end user satisfaction.

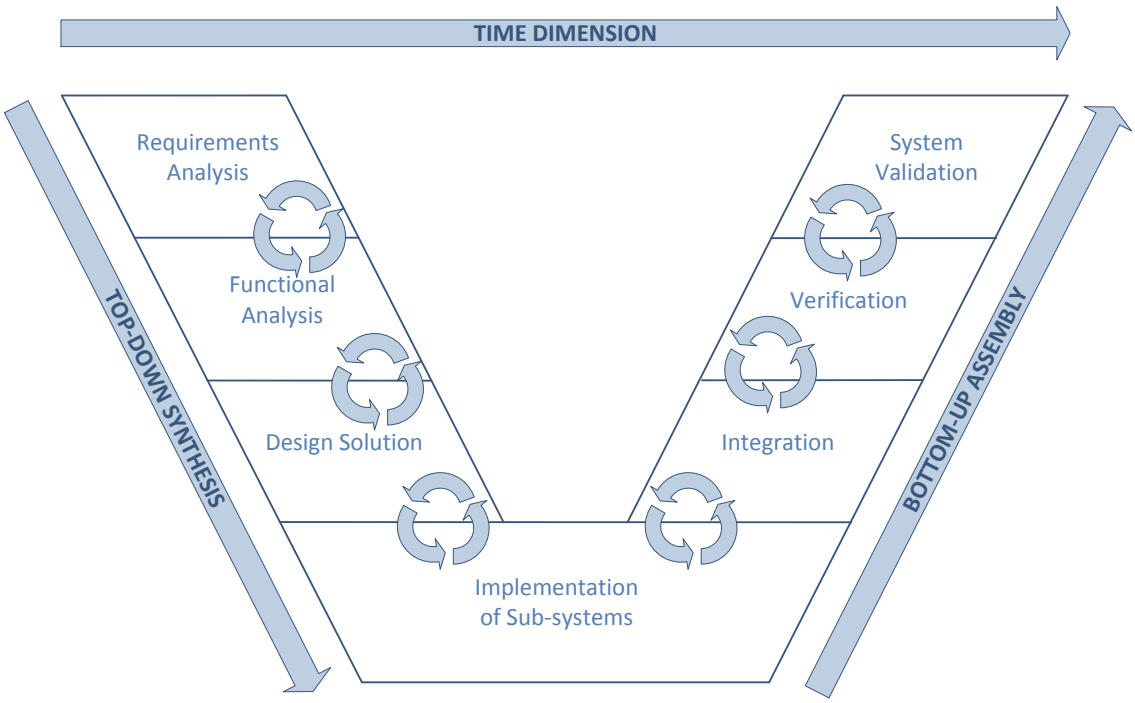

Figure 2-1: Vee Model

The four consecutive system releases and development cycles each following the Vee model as can be seen over time in Figure 2-2. The releases are named A, B, C and the Final Release. At the moment of Release A has been successfully demonstrated and validated which means that the initial requirement analysis phase, the first design, a first round of implementation and integration and testing has been done. The demo took place at an end user workshop at the 9th of October 2018 in Glasgow, Scotland.

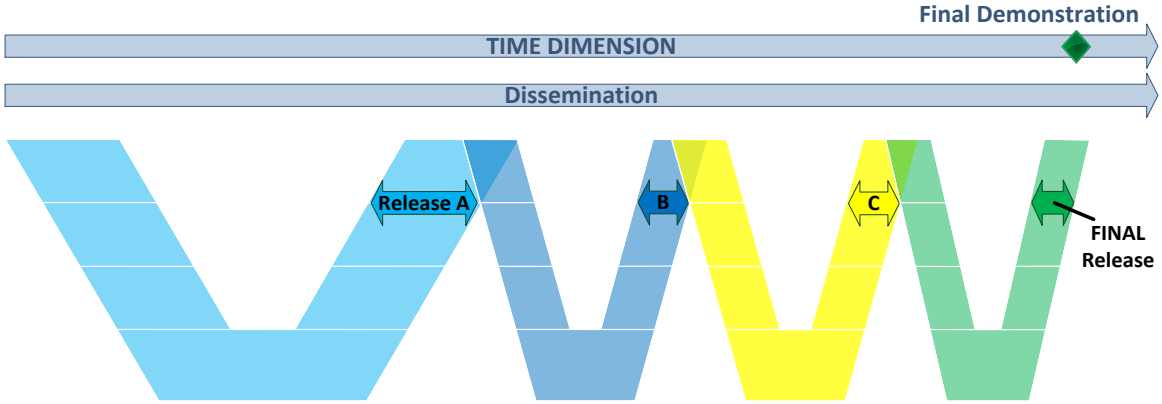

Figure 2-2: Development and system release concept

For the preparation of the demo the technical partners organized multiple “dry runs” for verification. The end user partners provided stories to follow during the demo and during the dry runs it has been tested if the needed features are available and work properly. Each dry

run was following one of two stories provided. More information about the stories and the demonstration can be found in D3.5 – HEIMDALL Demonstrations – Issue 2 [4].

During the demo, feedback from the users was collected and was analysed which lead to an update of the user requirements of the systems presented in D2.7 – HEIMDALL Requirements Report – Issue 2. The analyses were prepared by the technical (TM) and the stakeholder manager (SM) in order to keep the communication loops short. Questions to the technical partners have been forwarded by the TM and questions to the stakeholders by the SM, respectively. Often the questions could directly be clarified by the TM and SM. After the preparation of the user requirements they were reviewed by the partners to ensure consistency. System requirements were created by technical partners followed by technical requirements.

The consortium at the moment is converging towards the finalisation of the technical requirements and updating the module specifications to consider the update of the user requirements. In terms of the Vee model: We are closing the design solution step and entering in the next implementation phase.

2.1 Timing

In Figure 2-3, the relevant time window of the calendar of the project is shown. The figure shows the important items and deliverables for WP1 and WP2 for the months M14 – M25. According to the plan, the demo should have been at end of M17 followed up by the requirements analyses phase. Regarding the second iteration of the HEIMDALL prototype, it is expected to have a first version of release B in M23 so that it can be presented at M24 in demo B. At the moment the consortium is at the edge of designing and implementing the sub systems, which means that there is a small delay of about a month compared to the original plan. This is due to the slightly later date of demo A and the duration of the requirements analyses which was longer than expected. Nevertheless, it is expected that time still will be enough to have the release B on time, since the integration is always focusing on the most mature and important modules first.

Schedule

Milestones	Deliverable Final Version			Demonstrator								
Internal MS	Deliverable Draft Version											
				MS 2 - Submodule Specf	Demo 1- Release A		Current Month	Jan.19			IMS 2 - Demo 2: System Release B	
WP1	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25
Item due												D1.4
Responsible partner												DLR-KN
Required input		Quarterly Progress Report			Quarterly Progress Report			Quarterly Progress Report			Quarterly Progress Report	
Input responsible partner		All			All			All			All	
WP2	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25
Item due	D2.1				D2.2 Draft		D2.2 D2.7 Draft		D2.7			D2.3 Draft
Responsible partner	DLR-KN				DLR-KN		DLR-KN		DLR-KN			DLR-KN
Required input	Release A submodules		Release A verified		IR + Interface document User Requirements			Release B submodules		Release B verified		IR + Interface document + User Requirements
Input responsible partner	WPL(4-6)		SPH		WPL(4-6) + PCF			WPL(4-6)		SPH		WPL(4-6) + PCF

Figure 2-3: Calendar M14 – M25

2.1.1 **Milestones**

At the moment of submitting this deliverable in M20, according to the calendar from system engineering perspective the following milestones have been completed between this issue and the previous (D2.6 [5]):

- MS 2 – “Submodule Specification” which includes the delivery of the following relevant technical deliverables to the EC:
  - D2.1
  - D3.2
  - D4.1
  - D4.4
  - D4.7
  - D4.13
  - D5.1
  - D5.4
  - D6.1
  - D6.4
  - D6.7
  - D6.10
  - D6.14
  - D6.15
- Release A

All deliverables and technical specifications have been submitted by now to the EC besides D4.13 which is delayed a bit. It is expected to have a final version of this deliverable soon so that the milestone can be closed. The modules for release A were delivered in time for the demo A and were validated. Deviations from requirements planned are expected and managed following the agile approach of the project as can be seen in the following sections.

3 Releases

For each release, this section documents the features to be included linking them to the system design. The current issue presents the integration plan for Release B in section 3.1 and specifies the implementation plan and a preliminary version of all features and releases in section 3.2. Note that the here presented plan still can vary over the next releases since the requirements management of the project follows an agile approach, i.e. modifications on the requirements are possible and likely to happen with a close communication loop to the end user.

3.1 Integration Plan

Integrating a module in HEIMDALL means implementation of the necessary interfaces and connecting the module with the system, i.e. connect it with the service platform (SP) as middleware and integrate the features in the graphical user interface (GUI) so that the output to be visualised and the module controlled by the user. The integration plan was introduced in D2.6 [5]. One major modification has been done compare to the initial version: the catalogue and the dedicated interface are switched to release C, since the design is currently still ongoing and the implementation of this module is more complicated than originally planned.

The implementation and integration plan presented in Table 3-1 shows when the first version of a specific module is planned to be integrated in the overall system.

Table 3-1: Integration Plan

Module	**Release A**	**Release B**	**Release C**
GUI	X		
User and role management	X		
Service platform	X		
Earth observation		X	
Aerial based data			X
Landslide monitors			X
Crowdsourced and first responders data	X		
External systems	X	X	X
Fire simulation	X		
Flood simulation		X	
Landslides		X	
Scenario management	X		

Risk and impact assessment products and workflows		X	
Impact summary		X	
Scenario matching			X
Decision support			X
Satellite communication			X
Information gateway	X		
Catalogue			X
Interface to other local units			X

3.2 Implementation Plan

The following tables present for each single module the features to be implemented and the release at which they would be implemented. They are sorted according to the products introduced in [7] and [8]. The second column shows the format of the provided product. In the next columns the ID of the technical requirement (TR) linked to the product is presented. TRs are features of the system that will be implemented and they are further specified in the corresponding deliverable of the module and the requirements report D2.7 [9]. For each requirement the planned release is shown in the fourth column, i.e. a first version of the feature will be implemented for this release.

This iterative approach of HEIMDALL, allows the definitions and implementations of the TRs to evolve during the project so a final version of each requirement will first be available for the final demonstration. The next column shows the release the TR was actually implemented if it was release A. This is a kind of checklist, making possible to track ongoing implementation work and helping to identify deviations from the originally planning.

Table 3-2: Release Schedule GUI

Module	**GUI**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Display of information in the GUI	The format of each corresponding product.	TR_UI_1	A	A	Linked to another product
		TR_UI_3	A	A	
		TR_UI_4	A	A	
		TR_UI_5	A	A	
		TR_UI_6	A		
		TR_UI_8	A	A	Linked to another product

		TR_UI_9	A	A	Linked to another product
		TR_UI_10	B		Linked to another product
		TR_UI_11	A		Linked to another product
		TR_UI_12	A	A	Linked to another product
		TR_UI_13	A	A	Linked to another product
		TR_UI_14	C		Linked to another product
		TR_UI_16	C		Linked to another product
		TR_UI_17	B		Linked to another product
		TR_UI_18	C		
		TR_UI_20	B		Linked to another product
		TR_UI_21	B		Linked to another product
		TR_UI_22	C		Linked to another product
		TR_UI_23	B		Linked to another product
		TR_UI_24	B		
		TR_UI_25	B		
		TR_UI_26	B		Linked to another product
		TR_UI_27	C		
		TR_UI_28	C		
		TR_UI_29	C		
		TR_UI_30	C		
		TR_UI_34	C		
		TR_UI_36	B		
		TR_UI_37	B		

		TR_UI_38	B		
		TR_UI_39	B		
		TR_UI_43	A	A	
		TR_UI_46	B		
		TR_UI_47	B		
		TR_UI_49	B		
		TR_UI_50	B		
		TR_UI_52	B		
		TR_UI_53	B		
		TR_UI_54	B		
		TR_UI_56	B		
		TR_UI_57	B		
		TR_UI_58	C		
		TR_UI_59	B		
		TR_UI_60	B		
		TR_UI_61	C		
		TR_UI_62	B		
Provisioning of products and services to users	Product format	TR_UI_1	A	A	Linked to another product
		TR_UI_2	A	A	
		TR_UI_7	B		
		TR_UI_8	A	A	Linked to another product
		TR_UI_9	A	A	Linked to another product
		TR_UI_10	B		Linked to another product
		TR_UI_12	A	A	Linked to another product

		TR_UI_13	A	A	Linked to another product
		TR_UI_14	C		Linked to another product
		TR_UI_15	B		
		TR_UI_16	C		Linked to another product
		TR_UI_17	C		Linked to another product
		TR_UI_19	A	A	
		TR_UI_20	B		Linked to another product
		TR_UI_21	C		Linked to another product
		TR_UI_22	C		Linked to another product
		TR_UI_23	B		Linked to another product
		TR_UI_26	C		Linked to another product
		TR_UI_31	A	A	
		TR_UI_33	C		
		TR_DataFR_1	A		
		TR_UI_32	C		
		TR_UI_34	C		
		TR_UI_35	B		
		TR_UI_36	B		
		TR_UI_38	B		
		TR_UI_39	B		
		TR_UI_43	A	A	
		TR_UI_44	C		
		TR_UI_45	C		

		TR_UI_46	B		
		TR_UI_47	B		
		TR_UI_48	C		
		TR_UI_49	B		
		TR_UI_50	B		
		TR_UI_51	B		
		TR_UI_55	B		
		TR_UI_56	B		
		TR_UI_57	B		
		TR_UI_60	B		

Table 3-3: Release Schedule User and Role Management

Module	**User and Role Management**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Authentication	Comply with the HEIMDALL password policy Token format	TR_UeRM_02	B	A	
		TR_UeRM_03	B		Linked to another product. Initially planned for A.
		TR_UeRM_09	A	A	
		TR_UeRM_11	B		Linked to another product. Initially planned for A.
		TR_UeRM_12	A	A	Linked to another product. Initially planned for B.
		TR_SP_12	A	A	
Access control	Web interface/UI	TR_UeRM_03	B		Linked to another product. Initially planned for A.

		TR_UeRM_10	B		
		TR_UeRM_11	B		Linked to another product. Initially planned for A.
		TR_UeRM_12	C	A	Linked to another product
		TR_UeRM_13	B		
		TR_UeRM_14	B		
		TR_UeRM_15	B		
		TR_UeRM_16	B		
		TR_UeRM_17	B		
		TR_UeRM_18	B		
		TR_SP_12	A	A	
Admin console	Web interface/UI	TR_UeRM_04	B		
		TR_UeRM_05	B		
		TR_UeRM_06	B		
		TR_UeRM_07	B		
		TR_UeRM_08	B		
Account management console	Web interface/UI	TR_UeRM_07	B		
		TR_UeRM_08	B		
		TR_UeRM_12	B	A	Linked to another product. Initially planned for A.
User profile	JSON	TR_UeRM_01	B		
		TR_UeRM_10	B		
		TR_UeRM_12	B	A	Linked to another product. Initially planned for A.

Table 3-4: Implementation Plan Service Platform

Module	**Service Platform**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Georeferenced data storage service	OGC WMS/WFS/WCS	TR_SP_01	A	A	
		TR_SP_02	B		
		TR_SP_04	B		Dep. crowdsourcing
GIS database	REST API/JSON	TR_SP_01	A	A	
		TR_SP_02	B		
“Plain” data storage service	REST/JSON	TR_SP_03	A	A	
“Plain” database	Document and/or NoSQL storage	TR_SP_03	A	A	
Historic data service	JSON (comply with scenario format)	TR_UI_10	B		Could be moved to Scenario Management
Workflow invocation service	REST/JSON	TR_SP_05	B		
		TR_SP_08	C		
		TR_SP_09	B		
		TR_SP_11	C		
SP Monitoring	REST/file/JSON	TR_SP_09	B		
		TR_SP_11	C		
Interfaces with various services	Acquired data (either raw or processed) not provided HEIMDALL modules	TR_SP_06	A	A	
		TR_SP_07	A	A	
		TR_SP_10	C		
		TR_SP_13	A	A	
		TR_SP_14	C		

Table 3-5: Implementation Plan Earth Observation

Module	**Earth Observation**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Flood extent (semi-automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_2	A	A	Example products
		TR_DataEO_3	A	A	Example products
Burn scar (semi-automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_1	A	A	Example products
		TR_DataEO_3	A	A	Example products
Fire hot spots (semi-automatic)	ESRI Shapefile	TR_DataEO_1	A	A	Example products
		TR_DataEO_3	A	A	
Landslide extent (semi-automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_4	A	A	Example products
		TR_DataEO_3	A	A	Example products
Information about landslides (semi-automatic)	ESRI Shapefile	TR_DataEO_4	A	A	Example products
		TR_DataEO_3	A	A	Example products
Flood extent (automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_2	C		
		TR_DataEO_3	C		
Burn scar (automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_1	C		
		TR_DataEO_3	C		
Fire hot spots (automatic)	ESRI Shapefile	TR_DataEO_1	C		
		TR_DataEO_3	C		
Landslide extent (automatic)	GeoTIFF and ESRI Shapefile	TR_DataEO_4	C		
		TR_DataEO_3	C		
Information about landslides (automatic)	ESRI Shapefile	TR_DataEO_4	C		
		TR_DataEO_3	C		

Table 3-6: Implementation Plan Aerial Based Data

Module	**Aerial Based Data**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Geo-referenced alert signal	JSON	TR_DATASitu_6	A	A	
		TR_DATASitu_7	A	A	
		TR_DATASitu_8	C		
		TR_DATASitu_9	C		
		TR_DATASitu_10	C		
Pictures	JPEG	TR_DATASitu_9	C		
		TR_DATASitu_10	C		
Thermal Pictures	JPEG	TR_DATASitu_9	C		
		TR_DATASitu_10	C		
On-demand video stream	MPEG	TR_DATASitu_11	C		
Semi-autonomous flight	Python modules	TR_DATASitu_12	C		

Table 3-7: Implementation Plan Landslide monitors

Module	**Landslide monitors**				
Product-	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Terrestrial radar for landslide monitoring	Georeferenced shape files or 1D Plots (e.g. excel files)	TR_DATASituMon_1	B		Linked to another product
		TR_DATASituMon_2	B		Linked to another product
Geotechnical/hydrological	Database	TR_DATASituGeo_1	C		Linked to another product

sensors data for landslide monitoring		TR_DATASituGeo_2	C		Linked to another product
		TR_DATASituGeo_3	C		Linked to another product
Geodesic or topographic surveys	Raster/Vectorial files	TR_DATASituMon_1	B		Linked to another product
		TR_DATASituMon_2	B		Linked to another product
Near real-time terrain movement information	Report	TR_DATASituGeo_4	C		

Table 3-8: Implementation Plan Crowdsourced and First Responders Data

Module	**Crowdsourced and First Responders Data**				
Product	**Format**	**Linked Requirements**	**Release planned**	**Actual implemented**	**Comments (opt.)**
Authentication	Object represented by e.g. JSON	TR_DataFR_2	B	A	
Alerts receiver	CAP	TR_DataFR_3	A	A	
Hazard	Object represented by e.g. JSON	TR_DataFR_4	B		
Incident	Object represented by e.g. JSON	TR_DataFR_4	C		
First responders' location	Object represented by e.g. JSON	TR_DataFR_5	A	A	
Chat	XMPP	TR_DataFR_6	B	A	Work in progress; Limited functionalities implemented
Saving the map in Cache memory	PNG	TR_DataFR_7	B		

Table 3-9: Implementation Plan External Systems

Module	**External Systems**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Service-specific interfaces as plug-ins	Service API	TR_SP_05	B		
		TR_SP_08	C		
		TR_SP_09	B		
		TR_SP_11	C		Dependent on the maturity of services
Enterprise Service Bus	XML, JSON, binary data (videos, photos, documents etc.)	TR_SP_06	A	A	
		TR_SP_07	A	A	
		TR_SP_10	C		
		TR_SP_13	A	A	
		TR_SP_14	C		
Copernicus EO services	Raster, vector and KMZ, NetCDF, GRIB, Web API services.	TR_DataEx_01	A	A	Get data from EFFIS where layers concerning hot spots and burnt area (24h, 7d and 90d) are available through WMS.
GDACS information	- API/Web services including WMS - KML	TR_DataEx_01	C		Integration of that source of data
Meteorological and hydrological information	REST/JSON or XML files	TR_DataEx_04	A	A	
		TR_DataEx_05	A	A	
		TR_DataEx_06	B		depending on the service availability
Cartographic data	Shapefiles, GeoTIFF	TR_DataEx_01	A	A	
		TR_DataEx_02	A	A	
		TR_DataEx_07	B		depending on the service

					availability
		TR_DataEx_08	B		depending on the service availability
Census data	WPS.REST services and/or shapefiles, GeoTIFF	TR_DataEx_01	B		Dependent on the availability of data sources.
Critical infrastructure information	Shapefiles, GeoTIFF	TR_DataEx_01	B		Dependent on the availability of data sources. Link to GOIs
Asset location	GeoJSON	TR_DataEx_09	B	A (FR location through the mobile app)	
		TR_DataFR_05	B	A (FR location through the mobile app)	
Information received from drones	Georeferenced sensor data (i.e., hotspot identification)	TR_DataEx_13	C		
Crowdsourcing information from FRs	Georeferenced data (images, text, etc.) (GeoJSON object)	TR_DataEx_03	B		
		TR_DataEx_10	B		
		TR_DataEx_11	C		
		TR_DataEx_12	B		
		TR_DataEx_14	B		
Crowdsourcing information from the public	Georeferenced data (images, text, etc.) (GeoJSON object)	TR_DataEx_14	B		
		TR_DataEx_18	B		

Table 3-10: Implementation Plan Fire Simulation

Module	**Fire Simulation**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Time of	Raster in	TR_FFS_1	A	A	

arrival	GeoTIFF format	TR_FFS_3	A	A	Currently accepts one weather value for each weather parameter, for release B it shall accept multiple weather values (forecasted values)
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Fire perimeter	Vectorial output. In GeoJSON	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Minimum Travel Time (MTT) fire paths	Vectorial output. In GeoJSON	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Fire perimeter	Raster in GeoTIFF format.	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Flame length	Raster in GeoTIFF	TR_FFS_1	A	A	

	format.	TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Fire intensity	Raster in GeoTIFF format.	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Rate of Spread (ROS)	Raster output of the ROS of the fire in m/s and in GeoTIFF format	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Out of suppression capacity	Raster output in GeoTIFF	TR_FFS_1	A	A	
		TR_FFS_3	A	A	
		TR_FFS_4	A	A	
		TR_FFS_5	A	A	
		TR_FFS_7	A	A	
Adjusted forest fire simulations	Vectorial and raster outputs. Vectorial: In GML or GeoJSON Raster: GeoTIFF format	TR_FFS_2	B		To adjust simulations, firebreaks are a functionality of the simulator however it is not a product itself.
Effect of firebreaks	N/A	TR_FFS_8	C		To simulate taking into account the effects of firebreaks is a

					functionality of the simulator however it is not a product itself.
Measure of uncertainty	T.B.D.	TR_FFS_12	C		
Mountain ridges	Raster or vectorial output	TR_FFS_6	B		
Consolidation lines	Raster or vectorial output	TR_FFS_6	B		
Valley nodes	Raster or vectorial output	TR_FFS_6	B		
Vertical walls	Raster or vectorial output	TR_FFS_6	B		
Impact oriented fire paths	Raster in GeoTIFF format.	TR_FFS_9	C		
Forest fire impact relevance assessment	Vector or raster map of qualitative classes	TR_FFS_9	C		

Table 3-11: Implementation Plan Flood Simulation

Module	**Flood Simulation**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Real-time flood extensions (Simplified model)	Raster of binary values (flooded/not-flooded) in GeoTIFF format	TR_FLOS_1	B		
		TR_FLOS_2	B		
		TR_FLOS_3	B		
		TR_FLOS_4	B		
Real-time water depth (Simplified model)	Raster of binary values (flooded/not-flooded) in GeoTIFF format	TR_FLOS_1	B		
		TR_FLOS_2	B		
		TR_FLOS_3	B		
		TR_FLOS_4	B		
Flood extensions	Raster of binary values	TR_FLOS_5	C		

(Complete model)	(flooded/not-flooded) in GeoTIFF format	TR_FLOS_6	C		
		TR_FLOS_7	C		
		TR_FLOS_9	C		
Water depth (Complete model)	Raster of real values of water depth in GeoTIFF format	TR_FLOS_5	C		
		TR_FLOS_6	C		
		TR_FLOS_7	C		
Water velocity (Complete model)	Raster of real values of water velocity in GeoTIFF format	TR_FLOS_5	C		
		TR_FLOS_6	C		
		TR_FLOS_7	C		
Dynamic mapping tool (hydrological model and simplified hydraulic)	Raster of real values of water velocity in GeoTIFF format	TR_FLOS_8	C		
Measure of uncertainty	TBD	TR_FLOS_10	C		

Table 3-12: Implementation Plan Landslide Modelling

Module	**Landslide Modelling**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Terrain Movement Susceptibility map	GeoTIFF	TR_LS_1	A	A	
		TR_LS_2	B		
		TR_LS_3	A	A	
		TR_LS_4	A	A	
		TR_LS_7	C		
Trends of triggering conditions that can trigger terrain movements	Descriptive format e.g. JSON	TR_LS_5	B		Linked to another product
		TR_LS_6	B		Linked to another product

Scenarios of potential landslide warning areas based on triggering conditions evolution.	Descriptive format e.g. JSON	TR_LS_5	C		Linked to another product
		TR_LS_6	C		Linked to another product

Table 3-13: Implementation Plan Scenario Management

Module	**Scenario Management**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Scenario	Descriptive format e.g. JSON	TR_Scen_1	A	A	
		TR_Scen_2	A	A	
		TR_Scen_3	A	A	
		TR_Scen_4	A	A	
		TR_Scen_5	A	A	
		TR_Scen_8	A	A	
		TR_Scen_12	A	A	
		TR_Scen_15	A	A	
		TR_Scen_7	B	A	
		TR_Scen_9	C		Initially planned for B
		TR_Scen_11	B	A	
		TR_Scen_13	B	A	
		TR_Scen_14	B	A	
		TR_Scen_6	C		
		TR_Scen_10	C		
		TR_Scen_26	C		
		TR_Scen_27	C		

		TR_Scen_28	B		
		TR_Scen_29	B		
		TR_Scen_30	B		
		TR_Scen_31	B		
		TR_Scen_32	B		
		TR_Scen_33	B		
		TR_Scen_34	B		
		TR_Scen_40	B		
		TR_Scen_42	B		
		TR_Scen_43	B		
		TR_Scen_45	C		
		TR_Scen_47	C		
Decision	Descriptive object represented by e.g. JSON; drawing, georeferenced format for formalizing paths of decisions	TR_Scen_24	C		
Response Plan	Descriptive object represented by e.g. JSON	TR_Scen_18	A	A	In A the possibility to add response plan objects has been implemented; Next step: define with end users a response plan data structure
		TR_Scen_19	C		Initially planned for B
		TR_Scen_49	B		
Measure	Georeferenced object, e.g. GeoJSON	TR_Scen_25	C		

Lesson learnt	Descriptive object represented by e.g. JSON	TR_Scen_17	B	A	In A the possibility to add lesson learnt objects has been implemented; Next step: refine with end users the lesson learnt data structure
		TR_Scen_20	C		
		TR_Scen_48	B		
		TR_Scen_46	C		

Table 3-14: Implementation Plan Risk and Impact Assessment Products and Workflows

Module	**Risk assessment**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Multi-hazard risk	Raster or vector map of qualitative classes (low – medium – high)	TR_Risk_09	B		
		TR_Risk_23	C		
Human Impact Assessment	Raster or vector map of qualitative classes (low – medium – high)	TR_RiskWF_3	C		
		TR_RiskWF_8	C		
Human Exposure	Raster or vector density map	TR_Risk_05	B		
		TR_Risk_04	B		Collection process of suitable statistical information ongoing. Initially planned for B
		TR_Risk_20	C		
		TR_RiskWF_1	C		
		TR_RiskWF_5	C		
Physical	Vector map (e.g. building height,	TR_Risk_01	A	A	Physical Exposure data

Exposure	building function, etc.)				set will be provided by DLR-DFD: Main feature for Review Meeting Implementation
		TR_RiskWF_2	B		
		TR_RiskWF_6	C		
		TR_Risk_25	C		
		TR_Risk_02	B	A	
		TR_Risk_21	C		
		TR_Risk_17	B		
		TR_Risk_18	C		
		TR_Risk_10	B		
		TR_Risk_14	C		
		TR_Risk_22	C		
		TR_Risk_24	C		
Physical Impact Assessment	Vector map of percentage damage for e.g. building stock transportation networks and land use classes	TR_RiskWF_4	B		
		TR_RiskWF_7	C		
		TR_Risk_03	B		
		TR_Risk_06	B		Collection process of suitable statistical information ongoing
		TR_Risk_07	B		Collection process of suitable statistical information ongoing
		TR_Risk_08	B		
		TR_Risk_11	B		

		TR_Risk_12	C		
		TR_Risk_13	C		
		TR_Risk_19	B		
		TR_Risk_21	C		

Table 3-15: Implementation Plan Impact Summary

Module	**Impact Summary**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Impact summary	Descriptive format; JSON Object	TR_SA_19	B		
		TR_SA_20	C		
GOIs at risk; New: Physical impact summary	Descriptive format; JSON Object	TR_SA_1	A	A	Data structure will be revised for B to allow aggregation at AOI level
		TR_SA_3	A	A	
		TR_SA_6	B	A	
		TR_SA_7	B	A	
		TR_SA_17	B		
		TR_SA_18	B		
Economic impact summary	Descriptive format; JSON Object	TR_SA_16	C		
People at risk; Human impact summary	Descriptive format; JSON Object	TR_SA_2	C		Classification based on availability of Human Impact Assessment
		TR_SA_4	C		
		TR_SA_12	C		
		TR_SA_15	C		
Potential cascading effects/ hazards	JSON Object	TR_SA_8	C		
		TR_SA_10	C		
		TR_SA_13	C		

Hazard evolution information	JSON Object	TR_SA_9	C		
		TR_SA_11	C		
		TR_SA_14	C		
Situation Report	In standardized, XML-based message format such as EDXL-CAP or EDXL-SitRep	TR_SA_5	B		Final version depending from availability of scenario snapshot (first version can operate on scenario) and decision support products

Table 3-16: Implementation Plan Scenario Matching

Module	**Scenario Matching**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
List of similar scenarios	JSON Object	TR_Scen_22	C		
		TR_Scen_23	C		
		TR_Scen_35	C		
		TR_Scen_36	C		
		TR_Scen_37	C		
		TR_Scen_38	C		
		TR_Scen_39	C		
		TR_Scen_41	C		
		TR_Scen_44	C		

Table 3-17: Implementation Plan Decision Support

Module	**Decision Support**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Information about safe,	Descriptive and georeferenced	TR_DS_1	B		

significant infrastructure	objects where applicable, e.g. in GeoJSON format	TR_DS_2	B		
		TR_DS_5	C		
		TR_DS_6	B		Initially planned for C
Information about safe response infrastructure	Descriptive and georeferenced objects where applicable, e.g. in GeoJSON format	TR_DS_3	C		
		TR_DS_4	C		
		TR_DS_5	C		
		TR_DS_6	B		Initially planned for C

Table 3-18: Implementation Plan SatCom

Module	**SatCom**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
SatCom	TBD	TR_Com_13	C		

Table 3-19: Implementation Plan IG

Module	**Information Gateway**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
FR information service	SitRep, Scenario in the corresponding format (probably EDXL based)	TR_Com_4	C		Initially planned B
		TR_Com_5	C		Initially planned B
		TR_Com_6	C		
		TR_Com_7	C		
		TR_Com_8	C		
		TR_Com_20	C		
	JSON	TR_Com_18	C		
	JSON	TR_Com_19	C		
	SitRep, EDXL-DR or CAP	TR_Com_21	C		Linked to another product

Alerting service	CAP message	TR_Com_1	A	A	
		TR_Com_2	A	A	
		TR_Com_3	A	A	
		TR_Com_11	A	A	
		TR_Com_12	A	A	
		TR_Com_14	B		
		TR_Com_15	B		
		TR_Com_16	B		
		TR_Com_17	B		
		TR_Com_21	B		

Table 3-20: Implementation Plan Catalogue

Module	**Catalogue**				
Product	**Format**	**Linked Requirements**	**Planned for release**	**Actual implemented**	**Comments (opt.)**
Information Discovery Translation and mapping service	Shared content and metadata	TR_DSC_1	C		
		TR_DSC_2	C		
		TR_DSC_3	C		Initially planned B
		TR_DSC_4	C		Initially planned B
		TR_DSC_5	C		Linked to another product. Initially planned B
		TR_DSC_6	C		Linked to another product. Initially planned B
		TR_DSC_7	C		Initially planned B

		TR_DSC_8	C		Initially planned B
		TR_DSC_9	C		Initially planned B
		TR_DSC_10	C		Initially planned B
		TR_DSC_12	C		
		TR_DSC_13	C		
		TR_DSC_19	C		Initially planned B
		TR_DSC_20	C		Linked to another product. Initially planned B
		TR_DSC_21	C		Linked to another product. Initially planned B
		TR_DSC_22	C		Linked to another product. Initially planned B
		TR_DSC_20	C		
Collaboration and messaging	Shared content and metadata	TR_DSC_5	C		Linked to another. Initially planned B product
		TR_DSC_14	C		
		TR_DSC_15	C		
		TR_DSC_16	C		
		TR_DSC_20	C		Linked to another product. Initially planned B
		TR_DSC_21	C		Linked to another product. Initially planned B

		TR_DSC_22	C		Linked to another product. Initially planned B
		TR_DSC_17	C		
		TR_DSC_18	C		
		TR_DSC_19	C		
Interface to other local units	Data input by the user	TR_DSC_6	C		Linked to another product. Initially planned B
		TR_DSC_11	C		Initially planned B
		TR_DSC_20	C		Linked to another product. Initially planned B

3.3 Release A

As implementation plan for Release A, Table 3-21 summarizes the features scheduled for integration at this release. It includes for each main module the planned technical requirements (TRs) of features to be implemented for this release. For the sake of clarity the TRs are briefly described in the table, for more detailed information see [9]. According to the system release concept followed in HEIMDALL, the features implemented are a first version to be validated in Release A. The features will evolve during the project duration, based on the gathered feedback after each end user workshop that follows each release. In the same way,

Table 3-22 summarizes the features that will be implemented during the implementation phase but as standalone, i.e. to be integrated later release. In this way, it is possible to track also the progress of the features that are not integrated.

Table 3-21: Features implemented and integrated for Release A

Main Module	ID	TR brief description	Comments
GUI	TR_UI_1	User login	Implemented
	TR_UI_2	Customise settings	Implemented Default settings from the commercial map available.
	TR_UI_3	Show data	Implemented; FR and FCP locations completed
	TR_UI_4	Filter information, map layers, settings	Implemented

	TR_UI_5	Show information in a map	Implemented FR information available
	TR_UI_6	Information to differentiate between historical and live data	Not implemented for release A.
	TR_UI_8	Trigger Simulations, show results	Implemented
	TR_UI_9	Enable simulation settings	Implemented
	TR_UI_11	Notifications to the user	Not implemented; low priority for release A
	TR_UI_12	EO imagery	Implemented
	TR_UI_13	Include external services	Implemented
	TR_UI_19	Functionalities to create/ edit/ delete/ associate information to a scenario	Implemented
	TR_UI_31	Compose alert message	Implemented
	TR_UI_43	GUI reachable via internet	Implemented
User and Role Management	TR_UeRM_12	Single sign on/off	Login implemented.
	TR_UeRM_09	Support of standard protocols	JWT implemented.
Service Platform	TR_SP_01	Database to store GIS data	Implemented.
	TR_SP_03	Database to store sensor data	Sensor data not present in Rel. A. In any case the GIS DB is going to be used, since these data will be georeferenced.
	TR_SP_04	Receive and store georeferenced information from first responders	Implemented.
	TR_SP_06	Integrate multiple heterogeneous data sources using standard interfaces	Support for OGC services/interfaces.
	TR_SP_07	Integrate multiple heterogeneous data sources using proprietary interfaces	Stepwise integration. If the data sources used do not require proprietary interfaces this will not be satisfied. No need in Rel. A.
	TR_SP_12	Support multiple users operating simultaneously	Implemented.
	TR_SP_13	Facilitate the exchange of information with existing operational tools	The parts for Release A and if needed. Not needed in Rel. A.

Crowdsourced and First Responders Data (App)	TR_DataFR_1	Implementing a mobile application	Implemented
	TR_DataFR_2	Log in	Implemented
	TR_DataFR_3	App receives alert messages	Implemented
	TR_DataFR_4	Support exchange of information – sending photos, incident details, incident reports, user metadata etc.	Implemented partially – can send pictures.
	TR_DataFR_5	Track and display the location of first responders	Implemented
	TR_DataFR_6	Chat	Implemented
External Systems	TR_DataEx_01	Present the information as map layers	Implemented.
	TR_DataEx_02	Georeferenced base layer for the maps	Implemented.
	TR_DataEx_04	Meteorological information from weather services	Implemented.
	TR_DataEx_05	Hydrological information from available services	Implemented. Same information as the above TR.
Fire Simulation	TR_FFS_1	Run forest fire simulations	Implemented
	TR_FFS_3	Integrate the necessary weather parameters	Implemented
	TR_FFS_4	Simulations with multiple ignition points	Ongoing
	TR_FFS_5	Multiple simulations at the same time	Implemented
	TR_FFS_7	Different simulation parameters defined by the user	Implemented
Scenario Management	TR_Scen_1	Creating a scenario	Implemented
	TR_Scen_2	Creating a scenario from a potential or real hazard	Implemented
	TR_Scen_3	Compatibility with EDXL	Implemented
	TR_Scen_4	Accessing scenarios	Implemented
	TR_Scen_5	Modifying scenario parameters	Implemented
	TR_Scen_8	Defining scenario either as “real” or “simulated” scenario	Implemented
	TR_Scen_11	Accessing all information	Implemented

		associated to a scenario	
	TR_Scen_12	Associate further information to a scenario	Implemented
	TR_Scen_13	Deleting associated information from scenario	Implemented
	TR_Scen_14	Modifying associated information	Implemented
Information Gateway	TR_Com_1	Provide information to public	Not applicable
	TR_Com_2	Transmission of alert messages	Implemented
	TR_Com_3	Create alert messages	Implemented

Table 3-22: Features implemented in Release A implementation phase but to be integrated at a later phase

Main Module	ID	TR brief description	Comments
Earth Observation	TR_DataEO_1	Burn scars based on Sentinel-2 and hot spot detection based on MODIS data.	Ongoing; example products provided for release A
	TR_DataEO_2	Flood layer	Ongoing; example products provided for release A
	TR_DataEO_3	Download of EO products and their metadata	Ongoing
	TR_DataEO_4	Information about the landslide extent and landslide movement	Ongoing; example products provided for release A
Aerial Based Data	TR_DATASitu_6	Define a region of interest that the can be monitored by the swarm	Implemented
	TR_DATASitu_7	Define points of interest within the region of interest	Implemented
Landslide Modelling	TR_LS_1	Landslide propagation simulation to assess landslide susceptibility	Implemented
	TR_LS_3	Run simulation with user defined parameters	Implemented
	TR_LS_4	Landslide propagation simulation with multiple areas	Implemented
Scenario Management	TR_Scen_15	Accessing EO data associated to a scenario.	Implemented
	TR_Scen_16	Add information from the public to a scenario	Implemented
	TR_Scen_17	Manipulate lessons learnt and assign them to scenarios	Implemented with first data structure; must be refined for B

	TR_Scen_18	Manipulate response plans and assign them to scenarios	Implemented with first data structure; must be refined for B
Risk and Impact Assessment Products and Workflows	TR_Risk_01	Extraction of built-up area from Earth Observation data.	Ongoing (extraction from VHR images)
	TR_Risk_02	Identification of affected buildings and other infrastructure components based on hazard information	Implemented (based on observation based hazard extent)
Impact Summary	TR_SA_1	ISA information for GOIs at risk	Ongoing; First version implemented; Data structure will be revised for B to allow aggregation at AOI level
	TR_SA_3	Configuration of thresholds for the generation of GOIs at risk	Implemented
	TR_SA_6	ISA information for GOIs at risk in a specified geographical location	Ongoing; will be implemented for B with ISA information for a specified AOI
	TR_SA_7	Modify ISA information	Implemented

3.4 Release B

As implementation plan for Release B, Table 3-21 summarizes the features scheduled for integration at this release. It includes for each main module the planned technical requirements (TRs) of features to be implemented for this release. For the sake of clarity the TRs are briefly described in the table, for more detailed information see [9]. According to the system release concept followed in HEIMDALL, the features implemented are a first version to be validated in Release B.

In the same way,

Table 3-22 summarizes the features that will be implemented during the implementation phase but as standalone, i.e. to be integrated later release. In this way, it is possible to track also the progress of the features that are not integrated.

Table 3-23: Features implemented and integrated for Release B

Main Module	ID	TR brief description	Comments
GUI	TR_UI_7	Read/edit/add metadata	
	TR_UI_10	Display and distinguish operation modes	
	TR_UI_15	Administrator role privileges	
	TR_UI_17	Create/store/edit/delete/access incidents	
	TR_UI_20	Modify/store information related to a scenario	
	TR_UI_21	Manage lessons learnt	
	TR_UI_23	Search scenarios based on a set of parameters	
	TR_UI_24	Risk assessment information	

	TR_UI_25	Create/edit/delete/modify response plans	
	TR_UI_26	Manage situational assessment information	
	TR_UI_33	Set a scenario as active	
	TR_UI_35	Customise appearance	
	TR_UI_36	Display system information	
	TR_UI_37	Display AOI	
	TR_UI_38	List operation modes	
	TR_UI_39	Playback feature for simulations	
	TR_UI_46	List of inputs for an active scenario	
	TR_UI_47	Link information to scenarios	
	TR_UI_49	Impact summary within the selected AOI	
	TR_UI_50	Filtering incident information	
	TR_UI_51	Indicate/link GOI information	
	TR_UI_52	Map toolbar	
	TR_UI_53	Save login details locally	
	TR_UI_54	Radio/selection buttons	
	TR_UI_55	Performing system functions for an active scenario	
	TR_UI_56	Weather map and forecast information	
	TR_UI_57	Restore session or create new session	
	TR_UI_59	Display UTM co-ordinates and search	
	TR_UI_60	Pre-formatted table for scenario and simulator parameters	
	TR_UI_62	Highlight affected roads	
User and Role Management	TR_UeRM_01	The UeRM shall store the preferences of the users in their private user profile	Main functionality implemented, Ongoing actions to add the necessary preferences.
	TR_UeRM_02	The UeRM shall allow the system administrator to manage the configuration of the UeRM	Implemented.

	TR_UeRM_03	The UeRM shall allow the system administrator to enable and disable features	Partially implemented. Ongoing
	TR_UeRM_04	The UeRM shall allow the system administrator to manage roles and permissions assigned	Implemented
	TR_UeRM_05	The UeRM shall allow the system administrator to manage users	Implemented
	TR_UeRM_06	The UeRM shall provide an admin console	Implemented
	TR_UeRM_07	The UeRM shall provide an account management console	Partially implemented
	TR_UeRM_08	The UeRM shall allow the user to grant access to other users	Ongoing
	TR_UeRM_10	The UeRM shall store the roles, the users, their roles and profiles.	Implemented
	TR_UeRM_11	The UeRM shall maintain a list of login and logout operations	Ongoing (to expose this functionality to the users)
	TR_UeRM_13	Scenario deletion	Ongoing
	TR_UeRM_14	Deletion of scenario and lessons learnt templates	Ongoing
	TR_UeRM_15	Modification of scenario information	Ongoing
	TR_UeRM_16	Modification of map symbology	Ongoing
	TR_UeRM_17	Creation of map layers	Ongoing
	TR_UeRM_18	IG access (send alerts)	Ongoing
Service Platform	TR_SP_02	The SP shall provide a database to store EO data	Implemented
	TR_SP_04	The SP shall receive and store georeferenced information from first responders	Ongoing, in collaboration with T5.3
	TR_SP_05	The SP shall provide means to configure its operational parameters	Ongoing
	TR_SP_09	The SP shall run on virtualised IT infrastructures	Implemented
	TR_SP_10	The SP shall be easily extended with new sensors, modules, etc.	Ongoing
Crowdsourced and First Responders	TR_DataFR_7	Map of the AOI in the cache memory	

Data (App)			
	TR_DataFR_4	Send media to HEIMDALL system	
External Systems	TR_DataEx_01	Present information about critical infrastructures	Implemented, able to receive GOIs as a map layer.
	TR_DataEx_03	The system shall assign data received from a first responder to a specific incident	Able to receive data; assignment to scenario ongoing
	TR_DataEx_06	The system shall access meteorological information from private stations/users.	Dependent on available services.
	TR_DataEx_07	The system shall access the information of soil characteristics, elevations and landslide inventories available in the simulation area	Ongoing
	TR_DataEx_08	The system shall access and display pre-defined potential damage map information for a respective region.	Ongoing, a sample impact map was displayed for Release A.
	TR_DataEx_09	The system shall show the location of assets on the map	Implemented for FRs, where location was received through the mobile application.
	TR_DataEx_12	The system shall allow the deletion of information received from first responders.	Ongoing
	TR_DataEx_14	The system shall be able to receive incidents through the crowdsourcing application.	Ongoing, in collaboration with T5.3
	TR_DataFR_05	FR location	Implemented for FRs, where location was received through the mobile application.
Fire Simulation	TR_FFS_2	To adjust past fire spread simulations	
	TR_FFS_6	Estimate the geomorphological elements	
Flood Simulation	TR_FLOS_1	Simplified flood inundation simulation.	
	TR_FLOS_2	Simplified inundation model	
	TR_FLOS_3	Adjust of past inundation simulation	
	TR_FLOS_4	Simplified simulations using multiple discharge input points	
Landslide	TR_LS_2	Delineate information on	

Modelling		source areas	
	TR_LS_5	Access weather data	
	TR_LS_6	Delineate safe and unsafe areas	
Scenario Management	TR_Scen_7	Delete scenario	
	TR_Scen_28	Associate geotagged pictures to a scenario	
	TR_Scen_29	Create a scenario with weather data only	
	TR_Scen_30	Store extended weather parameters	
	TR_Scen_31	Store weather forecast in different fixed time frames	
	TR_Scen_32	Mark current weather conditions as verified by a field user	
	TR_Scen_33	Store area of scenario	
	TR_Scen_34	Associate GUI screenshots to a scenario	
	TR_Scen_40	Store lifecycle phase	
	TR_Scen_42	Store status	
	TR_Scen_43	Store urgency	
	TR_Scen_48	Updated lessons learnt data structure	End user input on data structure required
	TR_Scen_49	Updated response plan data structure	End user input on data structure required
Risk and Impact assessment	TR_RiskWF_2	Estimation of the physical exposure	
	TR_RiskWF_4	Assessment of the physical impact	
	TR_Risk_03	Estimate the expected impact based on the identified affected components, damage/vulnerability functions and the simulation/EO products	
	TR_Risk_04	Estimate the number of affected people	
	TR_Risk_05	Integrate information on monetary values and based on this estimate the impact	
	TR_Risk_06	Preliminary risk information products based on end user knowledge	

	TR_Risk_07	Provide the hazard extent to be displayed	
	TR_Risk_08	Generate risk assessments for forest fires, floods and landslides	
	TR_Risk_09	Consider cascading effects on vulnerability	
	TR_Risk_10	Integrate data sets of infrastructures	
	TR_Risk_11	Identify infrastructures not affected	
	TR_Risk_17	Information on the municipality membership	
	TR_Risk_19	Expected physical damage based on identified assets/GOIs	
Impact Summary	TR_SA_5	EDXL.-based situation report for scenarios	
	TR_SA_6	ISA information for GOIs at risk in a specified geographical location	
	TR_SA_7	Modify ISA information	
	TR_SA_17	Total percentage of damaged GOIs in AOI	
	TR_SA_18	Total degree of physical damage in AOI	
	TR_SA_19	Simple filtering of ISA Information	
Information Gateway	TR_Com_14	Different levels of predefined areas	
	TR_Com_15	Different types of areas	
	TR_Com_16	Different types of users when message is private	
	TR_Com_17	Multi-channel capabilities	
	TR_Com_21	Share pictures	

Table 3-24: Features implemented in Release B implementation phase but to be integrated at a later phase

Main Module	ID	TR brief description	Comments
Aerial Based Data	TR_DATASitu_12	Drones semi-autonomous mode. Permit an operator to command a waypoint. Additionally, permit an operator to steer camera of the drone	There will be a drone in the swarm that will be dedicated to this task. This drone will not fly in autonomous mode. It will be spare in case the user wants

		that is in semi-autonomous mode.	to fly in semi-autonomous mode.
Landslide monitors	TR_DATASituMon_1	Storing of new data	
	TR_DATASituMon_2	Operate with variables	
Decision Support	TR_DS_1	List of safe response infrastructure in AOI	
	TR_DS_2	Configuration of thresholds	
	TR_DS_6	Transparency on used criteria and metrics	

4 Progress and Status of Implementation

As mentioned in section 2 the modules for release A have been implemented. The implementation phase was followed by the integration and lab validation which resulted in the first demonstration of the HEIMDALL system. During the integration and lab validation phase the technical team of HEIMDALL performed refinement of the various modules and corrected errors with regards to the functionality and system interfaces. Then, the feedback from the demonstration was collected and analysed, in collaboration with WP3 activities, which led to updated requirements and specifications driving the implementation (WP4-WP6) and integration activities (WP2).

4.1 Status of Implementation in WP4

In T4.1, SPH has released the first version of the Service Platform (SP) which has been demonstrated in the release A and EUW2 event. This first integrated version of the SP provides the necessary databases and interfaces, facilitating the storage of information and the data exchange among the various HEIMDALL modules. The HEIMDALL components interact with the SP for two purposes:

- for sending and retrieving data
- for triggering workflows.

Data exchange is mainly performed over HTTP directly to the SP Data repository. Geospatial data are published/retrieved via the OGC-compliant services (WFS, WCS) as well as fully rasterised via the WMS service. In addition, a REST-based interface is available. Sensor data is exchanged via the OGC SOS service, while generic data can be published and retrieved via a proprietary HTTP REST interface. The current version of the SP facilitates the communication among the Scenario Management, UeRM, IG, and FFS components, as well as offers the required chat functionality to the platform's users. Preliminary draft from the release A has been incorporated in the SP, namely extensions regarding the legend information and the notifications service. Furthermore, D4.1 has been delivered.

In T4.2, the first version of the UeRM has been implemented and integrated in the HEIMDALL system. This preliminary version has been part of the release A and EUW2 demonstration providing user login and the generation of valid JWT tokens. The user management API, as well as the settings management API, has been defined and implemented. The target for this functionality is release B, however, the UeRM is already operational within the HEIMDALL platform. The status of the UeRM requirements and the testing and validation results are documented in D4.4.

Under T4.3, modifications of the GUI is being made based on the feedback from the demonstration as part of release A. Work has mainly progressed on

- Active scenario selection
- Moving simulation controls into scenario screens
- Moving alerts creation controls into scenario screens

In T4.4 a virtual machine is set up for the catalogue and currently preparations for connecting it to the HEIMDALL system are ongoing.

In T4.5 a first version of the information gateway has been implemented and integrated within the HEIMDALL system. The IG includes all features necessary for alerting the public based on the Common Alerting Protocol (CAP). The module was part of release A validated in the demo.

4.2 Status of Implementation in WP5

In T5.1, the implementation of the EO products pipelines has progressed as follows:

- **MODIS:** The implementation of the automatic hotspot service for wildfire detection based on data of the Moderate Resolution Imaging Spectroradiometer (MODIS) is finalized.
- **Sentinel-2 burn scar processing service:** With regard to the Sentinel-2 burn scar processing service, a prototypical burn scar processor has been implemented since the beginning of the project. Within the last months work has been accomplished to automate the processing chain by implementing an automatic ingestion of the Sentinel-2 data into the service and a method for automatically selecting appropriate pre-event data sets. Currently the processor is extensively tested and further developed with a focus on classification accuracy and transferability. The processing effectivity could be increased by implementing the capability of parallel computing. Further, current work focuses on reducing uncertainties related to cloud shadows and the similarity between burn scars and harvested agricultural land.
- **Fire severity estimation:** Two different approaches to map fire severity need to be distinguished depending on the characteristics of the images being used:
    - Images with SWIR channel (Sentinel-2, Landsat-8, Worldview-4 in some cases, etc.). This method is straight forward and widely used especially by the US Fire Science community (USFS). The method uses the dNBR to indicate the ecological impact of a fire on a landscape. Hence, the need to maintain the terminology used. Low and high severity does not mean a higher or lower level of fire but indicates what has been the loss in terms of vegetation due to the fire. This is the ecological severity.
    - Images without SWIR channels (SPOT 6/7, Pléiades, WV-2, WV-3, and WV-4 in most of the cases). This method is a stop gap that indicates vegetation presence or not within the fire affected areas before and after a fire and within the burn scar. The images used for demo A did not have SWIR channels. An experimental method has been used which is based on pre and post normalized difference vegetation index NDVI differences. This method needs to be standardized to be more robust in order to compare the fire severity between different areas.
- **Sentinel-1, Sentinel-2, TerraSAR-X and VHR optical data-based flood processing chains:** The implementation of the complete processing chains for automatic flood detection based on Sentinel-1 and TerraSAR-X data is finalized. Currently, the processors are extensively tested within different test areas with a focus on classification accuracy, transferability and processing effectivity. A second version of WATEX, the automatic flood processing chain for optical data, has been implemented and tested with Sentinel-2 and VHR data over several flood events across Europe and worldwide. This second version of the flood chain is now ready and operational. A third version of WATEX is in development in order to improve the results. The automatic generation of samples is unchanged, but WATEX v3 will use another supervised learning model: the Support Vector Machine. The script of this automatic WATEX v3 tool is using the ORFEO Tool Box (OTB). This version 3 is in the testing and improvement phase, it should be ready before the Demo – release C of the project.
- **Sentinel-2 landslide processing chain:** The first version of the automatic landslide extraction chain is now ready (SlidEx v1). Using any optical data with an infrared and red band as input, the tool first extracts zones with a high NDVI decrease. The result is corrected using a DEM; only areas with a slope higher than 10° are kept. A cloud mask is created to remove false positives. The mask is computed using a decision tree which is optimized for Sentinel-2 data. The resulting mask being restrictive on cloud, it's extended using a flood fill algorithm which allows removing more false positives. The next version of the tool is in development, which will include a morphological analysis to focus even more on realistic objects from the pixel oriented extraction.

- **Sentinel-1 landslide monitoring:** The development of the processing chain dedicated to Sentinel-1 data-based landslide monitoring in the Catalonia region is complemented. Using the deformation maps obtained through the interferometric processing, the developed tools are able to classify areas with different deformation behaviours. A quality index is also provided to the user to improve the analysis of the active deformation areas.

Example products related to all processors have been provided for release A and demonstrated during the second End User Workshop in October 2018.

In T5.2, the work has progressed in both the MAVs and in-situ sensors parts. Concerning the MAVs, multiple field experiments were carried out. These experiments allowed us to test our "light" version of the system: a version that permits the deployment of drones as autonomous sensor-carrying platforms. Results of the experiments and feedback received from colleagues will contribute to the further development of the system. Additionally, we worked on the planning of a campaign that will be carried out together with firefighter partners from Catalonia. In this campaign, we aim to collect data of hotspots. Thanks to this data, we will be able to derive a hotspot detection algorithm.

Concerning in-situ sensors, data from sensors is being collected continuously, and periodic reports are being issued. All these contents will be available in the HEIMDALL in-situ sensors module when this will be implemented in release C. The API is being designed and sample input/output data is going to be prepared for testing.

In T5.3, a first version of the first responder application has been developed, supporting user login and exchange of information with the rest of the HEIMDALL components through the SP. The application, including the chat functionality, has been integrated and demonstrated for the release A and EUW2.

In T5.4, the investigation on the external data and services that will provide added value to the HEIMDALL platform progressed. The prioritized service was the weather data information and this has been implemented. The data coming from external weather services are consumed by the fire and landslide simulators as well as the scenario management component, whereas the corresponding data are displayed in the GUI. The implementation of the weather service component splits areas of interest into a uniform grid and periodically polls the external weather service for each grid point. The retrieved data are stored to the geo-data repository of the SP. At request; cached values from the closest point via WFS as GeoJSON are served. This service has been integrated and demonstrated for the release A and EUW2.

In T5.5, the functionalities of the landslide susceptibility simulator that were foreseen for release A were implemented and the integration will be starting soon. At the same time the weather trends sub-module is being implemented. It is planned that both the susceptibility and the weather trends submodules will be ready for the release B.

With regards to the forest fire simulator, the functionalities foreseen to be demonstrated in release A have been implemented and demonstrated in release A, namely the services related to the simulation of the progression and behaviour of the fire. The forest fire simulator is currently running and will be improved with the functionalities to be implemented and foreseen for release B.

For what concerns the flood simulator, the development phase of the simulation engine core is completed. The simplified flood model has been tested in its first version in stand-alone mode. A real case study was used as test bed and a first comparison between the two types of simulators was done. In fact, the real case of Genoa flood on 2014, is a well-known event with regard the inputs and expected results. The results of the two types of simulators (extent and water depth in case of real-time simulation and extent, water depth and velocity in case of complete model simulation) fit well with the real observations of damages. At the moment, the development of a boundary condition for a real case is an ongoing work. In fact, it is necessary to implement many different possibilities as for example an upstream condition as

the dam accidents or downstream condition as sea dynamic. Moreover, the integration with possible punctual measures (i.e. raising or lowering levees) is under development.

4.3 Status of Implementation in WP6

In T6.1, the concept on risk analysis methodology applied with the RVA module was further developed and refined according to the feedback acquired in the end user workshops. This includes the documentation of methods applied during exposure estimation and impact assessment covering the various hazard types focused within the project. A first multi-hazard approach was introduced accounting for possible spatio-temporal overlaps of the individual hazards covered within the project. Possible cascading effects between the selected hazards were documented, in order to identify the relevant processes. The concepts defined within T6.1 are to be implemented in T6.2.

In T6.2, the implementation of the physical exposure methods was focused on the generation of 3D building model, since it serves as input during the human exposure generation. Therefore, building extraction from airborne laser scanning point cloud data has been implemented, serving as an input for the 3D building model, besides OpenStreetMap data and VHR imagery. Number of stories per building was derived performing regression tasks using building height, building size and building function as predictor variables. Complementary to the physical exposure data set, Land Use Land Cover (LULC) information and transportation networks were included. In addition to the geospatial information extracted, a generic building function taxonomy was developed in order to provide consistent cross-border building function information. Human exposure information was generated utilizing the high detailed 3D building model, with the information on number of stories, footprint and predominant building function. Two human exposure products have been derived using aerial interpolation techniques, such as dasymetric mapping. Daytime human exposure implies residence of employees in their workplace during daytime. The night-time human exposure implies the residence of all people in residential buildings during the night.

The implementation of the EO based impact assessment methods relies on the inputs provided by the Earth Observation data module and the physical and human exposure assessment sub-modules. The impact assessment is derived from the intersection of the real disaster event extent, extracted from post-event satellite imagery (and, in case of wildfires, event severity), with the physical and human exposure data. The results consist in separate buildings, roads, LULC and population layers highlighting the assets (buildings, road segments, LULC areas) and number of people affected, not affected or possibly affected by the disaster event; the EO based impact assessment layers keep the attributes provided by the exposure layers, such as the number of stories, building height, size and function, the road type, the LULC class etc. The resulting vector layers are furnished with a standard clearly visible symbology set which is easily integrated into the HEIMDALL platform.

In T6.3, first versions of the Impact Summary Generation Service (ISAS) and the Situation Report Generation Service (SITREP) have been set up. The ISAS functionalities that were foreseen for Release A were implemented with the focus on geographical objects of interest (GOIs) at risk such as potentially damaged buildings. Pre-defined GOIs in the La Jonquera area have been extracted from administrative data provided by the end users and integrated as a map layer in the service platform map server for display in the UI. ISAS intersects these pre-defined GOIs with fire perimeter products provided by the forest fire simulator and generates a summary of potentially affected GOIs. Product previews for future releases have been prepared, presented at the second end user workshop (EUW2) and validated by the end users. Based on validation results and discussions with the end users, AB members, ELSI and WP6 technical partners existing impact summary concepts have been refined. Accordingly, damage information at building level will be provided by impact assessment methods developed in T6.2. In contrast, ISAS will provide an impact summary on a higher level of aggregation containing total numbers of human and physical damage in areas of interest. The implementation of the new concepts is ongoing and integration will be starting soon.

Similar as in T6.3 in T6.4 decision support concepts have been revised based on results of discussions with the end users and AB members at EUW2. Accordingly, the Decision Support Service (DES) will provide a decision support summary on a higher level of aggregation containing total numbers and lists of safe (response) infrastructure in areas of interest. The implementation of this functionality is ongoing and intended to be ready in release B. However, integration is planned for release C. In addition, a new LULC change detection module for integration in the scenario matching module has been introduced and will be implemented in release C.

In T6.5, the Scenario Management Service (SMES) has been implemented and integrated for release A. Implemented functionalities include the creation, modification and access to scenarios including the association of additional information such as weather conditions, simulation results, EO products, response plans and lessons learnt. At EUW2 users had the possibility to “play” with the SMES during exercises using the corresponding UI functionalities. Feedback acquired by observations during the exercises, discussions, and questionnaires has been translated into updated user and system requirements which will be incorporated into the SMES in the upcoming releases. Scenario matching concepts, criteria and metrics have been evaluated together with the technical, end user and ELSI partners at EUW2. Updated user and system requirements will be considered in the development and implementation of the Scenario Matching Service (SMAC) planned for release C.

5 Conclusion

This deliverable presents the status and progress made in the HEIMDALL project. The standard Vee approach is used in an iterative manner in order to achieve four consecutive system releases A-C and a final one that will be validated in four dedicated system demonstrations.

The progress in terms of achieved milestones as well as in terms of the Vee model is presented. In MS 2, the sub module specification, a single deliverable is delayed while 11 technical deliverables have been delivered in time. The second iteration of user and system requirements are finalized. The effects on the module specification have been considered in the technical deliverables and implementation for Release B was kicked-off. Release A has been delivered and successfully validated in demonstration A.

The integration plan showing when a feature is planned to be implemented on a per module basis has been adapted. This integration plan considers also the maturity of the module as well as the plan for the demonstrations where each demonstration shall be dedicated to a specific hazard as shown in [4].

For each feature planned in the system the implementation plan presented in this document shows the planned release for the implementation. The actual implementation field here can be used as check box to see if the implantation was as planned of if adaptations were necessary.

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