FIRE-RES

Innovative technologies & socio-ecological-economic solutions for fire resilient territories in Europe

D5.1 Technical requirements and system architecture of the integrative software system

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Abstract: This report documents the work carried out in subtasks "5.1.1 Technical requirements" and "5.1.2 System architecture". This work sets the specifications basis for the development of subtask "5.1.3. Demonstration of an integrative system for estimating EWE risk and impact in real-time with HR weather data" where the Integrative System specified in this document shall be developed and the integration of several services and products takes place. The report lists the services and products to be integrated, the foreseen users and roles, the technical user requirements to be addressed and the specification of the architecture of the Integrative System.

Key words: Integrative System, Requirements, Architecture, EWE.

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Table of Contents

Acronyms

ANEPC: Autoridade Nacional de Emergência e Proteção Civil

API: Application Programming Interface

BC: Black Carbon

CAMS: Copernicus Atmosphere Monitoring Service

CSIC: Agencia Estatal Consejo Superior De Investigaciones Científicas

CFRS: Department d'Interior – Generalitat de Catalunya

CNRS: Centre National De La Recherche Scientifique

CTFC: Consorci Centre de Ciència i Tecnologia Forestal de Catalunya

CWD: Columnar Weather Data

DEM: Digital Elevation Model

ECG: Electrocardiogram

ECMWF: European Centre for Medium-Range Weather Forecasts

EFFIS: European Forest Fire Information System

EIS: External Information Sharing

EMS: Copernicus emergency management service

EO: Earth Observation

EWE: Extreme Wildfire Event

FCVR: Fuel Conditions and Vegetation Recovery

FLE: Fire Line Evolution

FRA: Fire Risk Assessment

FWISE: FORESTWISE

GA: Grant Agreement

GFS: Global Forecast System

GIS: Geographical Information System

GUI: Graphical User Interface

HPC: High Performance Computing

HR: High-Resolution

HRW: High-resolution surface weather forecast

IA: Innovative Action

ICGC: Institut Cartogràfic i Geològic de Catalunya

INESC TEC: Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência

IoT: Internet of Things

IS: Integrative System

ISA: Instituto Superior de Agronomia de Lisboa

ISSD: In Situ Sensors Data

ISP: Integrative System Platform

LLs: Living Labs

MITIGA: MITIGA SOLUTIONS SL

MU: Main Users

NCEP: National Centers for Environmental Prediction

OEDA: Occupational Exposure & Data Analysis

PyroCb: Pyrocumulonimbus clouds

PM: Particulate Matter

QA: Quality Assessment

SIM: EWE Simulation and Impact Assessment

SIM_ATM: EWE pyro convection and Coupled Effects module

SPD: Smoke Plume Dispersion

SPIRE: SPIRE Global Luxembourg SARL

SU: Secondary Users

TSYLVA: Tecnosylva

UARM: User Access and Role Management

VOCs: concentration of flammable volatiles

WeSENSS: Wearable Sensors for Safety

WP: Work Package

XUNTA: Conselleria do Medio Rural - Xunta de Galicia

1. Introduction

This document addresses the work that is being performed in task "5.1. Development of an integrative system to support EWE decision-making" and in specific of subtasks "5.1.1. Technical requirements" and "5.1.2. System architecture". Based on the results of the previously mentioned subtasks, the report also provides the technical requirements and specifications needed for the development of the proposed Integrative System and integration of the addressed software solutions, to be implemented in subtask "5.1.3. Demonstration of an integrative system for estimating EWE risk and impact in real-time with HR weather data (IA 5.1)". Furthermore, it provides the specification of the Integrative System architecture (Section 6 of the present document), that shall allow a smooth integration of the several products generated within WP5 tasks.

Being the purpose of WP5 the development of advanced technology solutions to improve fire management decisions, with a special focus on the integration of new EWE related knowledge, several IAs have been proposed to provide ready to use products adjusted to address specific problems. In this regard, the main purpose of the Integrative System in FIRE-RES is to provide a modular platform that integrates several specific products and services to be generated in several WP5 tasks, and therefore creates a multifaceted range of information and solutions for better decision making.

An initial goal of the Integrative System, is to demonstrate and evaluate the proposed products and services, that will be developed in other tasks and subtasks of WP5, on the Living Labs (LLs). This demonstration process shall allow to test the capacities of the integrated services and products on real world environments. An additional goal that is considered, is the integration of the solutions into already exiting end-user's emergency management Systems, in the future. On this regard, it has to be considered that the proposed integrated system does not aim to create a new emergency management system nor to supersede any existing system already in use by end-users. Still, it pursues to make use of its modular architecture to enable a smooth integration of newly generated solutions into already exiting end-user's emergency management Systems, in order to further complement existing functionalities or tools.

Following a development process that starts from defining high level conceptual framework to specific tool specifications, the document starts defining broad application scenarios for the proposed the system (Section 2), and identification of the potential users of the system and its individual modules or services (Section 3). Then, based on discussions between the different FIRE-RES WPs as well as among the partners of WP5 in charge of specific tasks, it was decided and agreed which services and products shall be part of the Integrative System (Section 4), and tested in the LLs. Once the services and products that are to be integrated in the system are defined, together with a proposed

usability scheme, the document explores the specific technical end-user requirements that should be addressed for the development of the system with the corresponding solutions to be integrated and demonstrated (Section 5), and identifies technological specifications that should be followed to address the integration of the foreseen solutions in order to convey the previously identified needs and requirements (Section 6). Regarding the structure of the deliverable itself, the document is organised as follows:

- Section 1 introduces the present document, the addressed work, the purpose of the Integrative System as well as presents the structure of the deliverable.
- Section 2 describes the application scenarios of the services and products that are planned to be integrated into the Integrative System.
- Section 3 describes the potential users and respective roles in the use of the several services and products to be integrated.
- Section 4 lists and briefly describes the several services and products that are foreseen to be integrated into the Integrative System.
- Section 5 specifies the technical user requirements to be addressed by the several services to be integrated. Furthermore, it specifies those specific requirements that the Integrative System shall to take into account in order to integrate the services and allow their proper demonstration in the several LLs.
- Section 6 documents the architecture characteristics and specifications of the Integrative System to allow the integration of the several services, inputs and products which will set the basis for the developments to be carried out in task 5.3.1.
- Section 7 concludes the present document.

2. Application scenarios

This chapter presents the application scenarios of the Integrative System including the services and products planned to be integrated in it, i.e., the high-level use cases that relate to the main functionalities to be provided by the services and products to be integrated. These application scenarios have been identified through an iterative process between the WP5 partners that are going to provide and integrate technologies.

In this regard, the foreseen application scenarios aim to fulfil key end user needs and that are in line, at the same time, with the proposed WP5 GA working plan. The application scenarios address the several phases of the emergency management cycle – Prevention and preparedness; Detection and Response; Restoration and Adaptation as depicted in Figure 1.

Figure 1 Emergency management cycles addressed by the Integrative System application scenarios

The application scenarios that are foreseen to be addressed by the services and products to be integrated in the Integrative System platform are as follows:

- **Risk assessment scenarios** correspond to services related to the assessment of the situation through observations and simulation of the expected affectation and behaviour of a fire event or risk linked to it. This provides support in predicting the characteristics of the hazard taking action to mitigate the potential or occurring event. Even though this assessment can be carried out during any phase of the emergency management cycle, it is mainly performed before the hazard takes place in order to plan, mitigate and prepare for the moment the hazard occurs.

- **Disaster monitoring scenarios** correspond to services related to the ongoing monitoring of a risk or hazard, such as a forest fire and smoke, to monitor its evolution, as well as the monitoring of the first responders and resources on the field in the interaction with the risk or hazardous event.
- **Interoperability scenarios** correspond to services that support the interoperability of stakeholders, when collaboration is needed among forest fire analysts belonging to different agencies, to allow remote analysis assessment and the sharing of relevant information about certain situation(s) or event(s).
- **Landscape recovery scenarios** correspond to services and products that allow evaluating the affectation of the fire once suppressed, related to ecology and socioeconomic factors, as well as estimate how the affected forested areas are expected to restore and adapt to support the implementation of restoration actions.

3. Users of the services and products

This section introduces the users and their roles related to the services and products that are planned to be incorporated in the Integrative System. The specification of the users aimed to provide support and clarity about the technical requirements, in Section 5 of the present document, which also takes into account the foreseen users. In this regard, two different types of users' categories have been identified and defined according to the aim of use of the services and products: Main users and Secondary users. These two categories are explained as follows:

Main users (MU): Any responsible entity or authority that makes use of the services/products to directly manage a certain situation or incident. The responsible entity makes use of the corresponding functionalities for Organizational purposes.

Secondary users (SU): Any third-party organization (i.e., not an institutional entity as defined above) that exploits certain service(s) and/or product(s) not acting on behalf of the responsible entity or authority. The public is also included under this category, i.e., the citizens that are provided with information generated and published by the System. In this specific case, the information to be shared/made available to the public should be decided and shared by the authorities.

Inside each of these aforementioned users' categories we may define further sub-categories, as listed below in the following tables Table 1 and Table 2.

Table 1 Primary Users of the services and products integrated in the Integrative System

Main Users (MU)		
Type of users	Description	Role(s)
Authorities	The organization in charge of managing the incident and/or carrying out a certain analysis	- Management of the incident and health conditions of the responders. - Risk and impact assessment. - Sharing of information with other authorities and with the first responders themselves.
First responders	The practitioners and the vehicles deployed and those involved in the incident on the field	- Access to the system functionalities or part of these from the field through e.g., a mobile device or laptop. - Will act as sensing node/system to collect information for the system. These data will be used by the first responders and authorities for an enhanced decision making.
Forest managers	Entities in charge of managing a	- Access to products and services that support fire mitigation analysis.

	forested area and carrying out fire mitigation planning and vegetation treatments	- Risk and impact assessment.

Table 2 Secondary Users of the services and products integrated in the Integrative System

Secondary Users (SU)		
Type of users	Description	Role(s)
Private and public entities (Academia/research included)	Public or private entities that make use of the data and/or services of the system	Make use of some of the products and/or services made accessible by the system.
Public	The citizens in general that might have access to information made available through the system to increase awareness about a given situation	Access information made available through the system.

It should be noted that although these types of users have been identified, this specification is orientative, and is meant to identify potential types of users and not to leave out any potential user of the services and products that are going to be made accessible through the Integrative System. The main purpose of this definition has been to guide the definition of the technical requirements as well as to facilitate the specification of the Integrative System architecture. The users of the services and products to be integrated shall be defined and addressed in the specification of the concerned services and products that will be carried out in the several tasks and subtasks of WP5. The aforementioned tasks and subtasks, in which the corresponding services and products shall be developed, are mentioned in Section 4 “Services and products”.

4. Services and products

This section provides a brief description of the services and products that are foreseen to be developed and connected to the Integrative System of FIRE-RES for their demonstrative purpose in the LLs, where they shall be demonstrated. In this regard, the services and products will be developed in several tasks and subtasks of WP5. It is not the purpose of the Integrative System to develop these services and products neither to specify their technical aspects and characteristics in this deliverable. The Integrative System aims to provide the necessary means to integrate these, and give access to their functionalities once these have been developed and are available. Thus, this section provides a list with a brief description of the services and products to be developed throughout the several tasks of WP5 that are foreseen to be part of the Integrative System. Considering these group of services and products as a whole, they address the three fire management phases, i.e., i) prevention and preparedness, ii) detection and response and iii) restoration and adaptation. Each of the services and products are described under each application scenario, it expects to address, and includes a service/product numbering, to facilitate traceability with the requirements throughout the document. The listed services/products may address one or several Living Labs (LLs). These LLs will be used as basis for obtaining the corresponding necessary digital data and information for the development and functioning of each service/product.

4.1. Risk Assessment services

[RA1] Forest fire risk assessment

This service, to be developed in the framework of task "5.3.1. Extreme forest fire behaviour modelling" is expected to provide a daily forest fire risk assessment in the addressed LLs areas, to derive expected fire behaviour and fire risk outputs by performing thousands of fire behaviour simulations daily across the entire LLs territories and assemble these to obtain fire behaviour and risk products. In this regard, it is expected to make use of high-resolution weather data computed through High-Performance Computing (HPC) resources, terrain and vegetation fuel data (including fuel moisture information) to perform the daily risk forecast. The aggregation of the fire behaviour simulation results shall provide several fire danger metrics, that will provide the end user with the zones of the territory that presents higher risk for the corresponding metrics with the aim of supporting forest fire mitigation planning and vegetation treatments activities. Furthermore, during the development of the methodologies, methods will be explored to detect the associated probability of occurrence of extreme events to predict in advance the possible origin of extreme fire events in the LLs territories.

[RA2] High-Resolution Weather Forecast

A high-resolution surface weather forecast service is expected to be developed in the framework of task "5.2. Acquisition and integration of data from internal and external sources" to provide high fidelity surface weather information and data in the addressed LLs. This service can be used as an information source to provide reliable weather information to the end-user to support their analysis of weather patterns and associated fire risk assessments. It shall also be used as an input to the forest fire risk assessment service models to perform the daily forest fire risk assessment (developed in the framework of task 5.3.1). Furthermore, it shall be used as an input to the Extreme Wildfire Events (EWE) simulation service models to simulate the behaviour of the fire (developed in the framework of task 5.3.1) and as an input of the smoke cloud dispersion simulator (developed in the framework of task "5.3.2. Forest fire smoke behaviour modelling"). This high-resolution weather service is foreseen to be able to make use of mesoscale numerical weather prediction models that make use of HPC resources.

[RA3] Fuel conditions maps

Forestland fuel condition maps that will be elaborated based on Earth Observation (EO), optical data, fusion multi-hyperspectral datasets, and LiDAR data. Once the maps are generated these will be made available in the Integrative System. These maps will include detailed fuel conditions and moisture content proxies of the corresponding Living Lab, with their associated parameters, changes and tendencies. Also, Artificial Intelligence approaches will be used to analyse patterns, tendencies and potential anomalies. These data shall have two main purposes, i) to provide the end-users with detailed information about the fuel conditions over a temporal basis and moisture content proxies to support preventive measures, and ii) to be used as input data to the fire simulation behaviour and risk models to estimate the corresponding fire behaviour and risk. These products shall be developed in the framework of task "5.2.1. vegetation characterization based on Earth Observation (EO) data fusion and Artificial Intelligence (AI) over forestland ecosystems".

[RA4] Concentration of flammable volatiles (VOCs) in the atmosphere

Maps of the concentration of flammable volatiles shall be developed in the framework of task 5.2 and shall be made available through the Integrative System for the Portuguese LL. This map shall provide information about the concentrations of flammable gases in the Portuguese LL which has the potential to support the practitioners in identifying critical areas of the landscape that could potentially accelerate and worsen an ongoing forest fire that could lead to its transition into an Extreme Wildfire Event.

4.2. Data interoperability services

[IN1] Interoperability among international stakeholders on forest fire data sharing

The Integrative system shall integrate services that allow connecting and sharing forest fire related data to an emergency agency with the aim of demonstrating the access and sharing of relevant forest fire data among emergency agencies systems and stakeholders. It is important to note that interoperability in this case is understood as providing access to spatial data sets through network services, typically via Internet. In this regard, a data sharing channel is expected to be created among fire analysts in emergency agencies to be used when collaborative work among fire analysts from several regions and/or countries is needed. This channel shall be able to facilitate remote analysis, assessment, transfer of information, among other functionalities. These data interoperability services are foreseen to be developed in the framework of task "5.5. Improvement of interoperability among international stakeholders".

4.3. Disaster Monitoring services

[DM1] Forest fire simulation and impact assessment

The Integrative System shall integrate the services developed in the framework of subtask "5.3.1. Extreme forest fire behaviour modelling" that shall allow to operationally simulate forest fires, including EWE. These services, with its basis on the simulation capabilities of Wildfire Analyst [9][9] aim to provide near real-time forest fire behaviour modelling and spread prediction (providing forest fire behaviour results in minutes) to estimate how the fire is expected to behave, how it is expected to spread in the terrain and to understand the potential impacts and consequences of the fire. The models foresee to include also the modelling of crown fire as well as taking into account fire spotting phenomena during the spread of the fire. The forest fire impact information shall include the assets foreseen to be impacted, when and how these are expected to be impacted, the number of people expected to be affected as well as direct economic losses (in case economic information on infrastructures would be available in the corresponding LLs). The use of high-fidelity and high-resolution surface weather data, atmospheric stability data, as well as vertical wind profiles data shall allow having a better insight about the EWE processes and improving the fire simulation models and associated results through the input of these data. As a consequence, it shall provide an advance in the state of the art of operational forest fire simulation by better predicting extreme wildfire events.

Furthermore, it shall also integrate a simulator that is able to simulate the processes of pyro-convection and the analysis of coupled effects of fire behaviour and the atmosphere including the smoke dispersion. This is foreseen to be carried out by making use of HPC resources that shall allow to simulate such complex phenomena. Furthermore, throughout the project multiple EWEs will be simulated and analysed to build a dataset with detailed atmospheric fields of extreme fire events.

[DM2] Operational smoke plume dispersion modelling

Besides the operational forest fire simulation services, an operational smoke plume dispersion model will be developed in the framework of task "5.3.2. Forest fire smoke behaviour modelling" and integrated into the Integrative System. This atmospheric dispersion model shall predict the advance of the smoke plume, and track the concentration of its different compounds during a forest fire considering smoke source term (composition, emission rate, plume height, etc.), and meteorological drivers as input fields. The operational monitoring of the smoke plume shall support the user in the prediction of the smoke impact on the population and responders in the field, and shall allow triggering related preventive and mitigation actions.

[DM3] Columnar atmospheric weather data

A service to provide columnar atmospheric data from SPIRE satellites will be incorporated into the Integrative System with a two-fold approach. On one hand, to display an updated weather forecast of vertical atmosphere profiles to the end-user, including relevant weather variables (such as geopotential height, temperature, u-wind component, v-wind component, relative humidity, vertical velocity, absolute vorticity, cloud water mixing ratio, cloud ice mixing ratio) up to 20.000m of altitude in different isobaric levels (i.e., from 1 hPa to 1000 hPa). The forecasts will be produced several times per day (at 0:00, 06:00, 12:00, and 18:00 UTC), and the following lead times will be made available: i) 0-h (the analysis of the state of the atmosphere at the beginning of the forecast cycle), ii) Hourly forecasts until the 48-h, iii) 3-Hourly forecasts from 48-h to 120-h (5 days), iv) 6-Hourly forecasts from 120-h to 240-h (10 days). On the other hand, some atmospheric profiles shall be provided as inputs to the fire behaviour simulation models to allow a better prediction and simulation of EWEs.

These atmospheric weather data aims to provide support in anticipating changes and dynamics that may lead to the growth and fall of pyrocumulonimbus (PyroCb).

[DM4] Real-time information from the field during a forest fire

Services to obtain and display operational and real-time information is foreseen to be developed in the framework of task "5.2. Acquisition and integration of data from internal and external sources" and integrated into the Integrative System. The developments shall include multiple services: i) a service to display the past, the real-time and future evolution of the fire-line that is expected to be estimated with data processing methods and models using the location of firefighters on the field; ii) environmental and physiological wearable devices to gather and share occupational exposure values, including individual data visualization, metrics and alarms to support the management of the team; iii) environmental monitoring of air quality inside fire truck cabins. Regarding environmental devices, an innovative hose sensor to estimate the water dispended in the forest fire

suppression engines will be developed also in the framework of task 5.2. and integrated into the system. Also, an environmental weather station is expected to be incorporated in the fire engines to gather and provide near real-time in situ weather data.

[DM5] In situ and personal exposure smoke sensors

Besides the aforementioned services, smoke in situ fixed sensors is also foreseen to be deployed in the Galicia LL in the framework of task "5.3.2. Forest fire smoke behaviour modelling". Smoke sensors will be located in the field to monitor the air quality impacts of wildfires. This information will then be used to validate the performance of smoke propagation models. In addition to the fixed sensors, wearable monitors will be used in the Catalonia and Galicia LLs to monitor the exposure of the first responders to the smoke. The monitors will allow to measure the exposures of first responders during different types of actions, e.g., suppression at the water-line, in the control centre, or during manual suppression actions during the final phases of the fire. This will facilitate the implementation of exposure reduction strategies, for example withdrawing specific firefighters from the operation once certain exposure or dose thresholds are exceeded. The first year of the project (summer 2022) will be a pilot year and the data will not be integrated in the platform. After (and including) summer 2023, the data shall be available to the end-users through the Integrative system Graphical User Interface (GUI).

4.4. Landscape Recovery

[LR1] Vegetation recovery scenarios maps

Vegetation recovery maps are foreseen to be elaborated in the framework of task "5.2.1. Advanced vegetation characterization based on Earth Observation (EO) data fusion and Artificial Intelligence (AI) over forestland ecosystems (IA 5.3)" and integrated into the System with the aim of providing support to the users in the monitoring post-fire scenarios. These maps are planned to be elaborated in the aforementioned task by coupling Earth Observation data with ecological and socio-economic available data and factors, in particular geoinformation related to land cover, land use and forest inventories. Based on available optical E.O. satellite data, Artificial Intelligence approaches will be used to provide support in the definition of the recovery scenario, to detect existing patterns and to allow the early detection of potential anomalies.

[LR2] Severity of wildfires maps

Fire severity index maps will be elaborated in the framework of task "5.2.1. Advanced vegetation characterization based on Earth Observation (EO) data fusion and Artificial Intelligence (AI) over forestland ecosystems (IA 5.3)" and integrated into the System with the aim of providing support to the users in the assessment of forest fire severity and affectation of the landscape. The severity of forest fires cartography will be elaborated on a common basis with activity "[LR1] Vegetation recovery scenarios maps".

[LR3] Forest cover restoration and adaptation behaviour maps

Forest cover restoration and adaptation maps are foreseen to be developed in the framework of task "5.2.1. Advanced vegetation characterization based on Earth Observation (EO) data fusion and Artificial Intelligence (AI) over forestland ecosystems (IA 5.3)" and made available through the Integrative System. These are expected to address several forests covers at spatial and temporal basis to provide support in the analysis of measures to recover fire affected forested areas. Available E.O. satellite open data as well as land cover maps will define the latency and update of the [LR3] derived maps results.

5. Technical user requirements

It is important to follow a methodical system engineering process with the aim of designing and implementing the Integrative System and to integrate the services and products that are expected to be incorporated for the demonstrative purposes of the FIRE-RES project. In this regard, the first step has been to define together with the WP5 partners the main services and products that it is intended to integrate and make accessible. These are listed and briefly explained in Section 4 of the present document. Once these have been defined, user technical requirements have been derived by analysing the needs of the users in the use of these services and products in specific and of the Integrative System in general.

Several meetings have been held among the partners that are foreseen to provide and integrate innovative technologies in WP5 to define according to their expertise and expectations the services and products which of these should and can be part of the Integrative System. Jointly, these partners have defined and described the main services and products in Section 4 of this document. In the framework of task "5.2. Acquisition and integration of data from internal and external sources" it has been also discussed which LLs each of these services shall address as well as the necessary base data that shall be requested and gathered. This information will be documented inside the framework of task 5.2.

Furthermore, two workshops have been carried out inside the framework of WP1 to set the basis of FIRE-RES needs and expectations. A first workshop has been held in month 5 of the FIRE-RES project in Girona at CFRS premises to discuss jointly with end-users' organizations the needs of the project regarding EWE drivers, emergency management, EWE behaviour and factors. A second workshop was held in month 7 of the Project in Solsona, at CTFC premises to discuss fire resilient landscape related topics to set the basis that shall guide the several related tasks in FIRE-RES. The partners from WP5 proposed discussion topics addressed in these, participated in the workshops discussions and extracted relevant information that was taken into account by them to further define the services and products planned to be developed and provided in WP5 including those planned to be integrated in the Integrative System.

In a second step, the outcome of the workshops, together with the main services and products specification, has been used by the services and products providers inside WP5 to specify the technical user requirements. For this purpose, the template shown in Table 3 has been prepared and used.

Table 3 Technical user requirements template

Requirement ID.:		
User(s):		Service/product:
Description:		
Notes		
IA		

The several fields included in the template and their specification are as follows:

Requirement ID: ID that identifies the user requirement in a unique way. The following structure is followed:

US_REQ_USR_SP_No

Where "SP" refers to the numbering of the service/product to which the requirement belongs to (i.e., according to the services and products code included in Section 4) and "No" is the corresponding requirement numbering inside the service/product group of requirements.

User: This field identifies the type(s) of users to which the requirement is related and according to the category of end-users defined in Section 3 of this document.

Service/product: This field identifies the Service or Product to which it corresponds to. The numbering corresponds to the code of the services and products defined in Section 4.

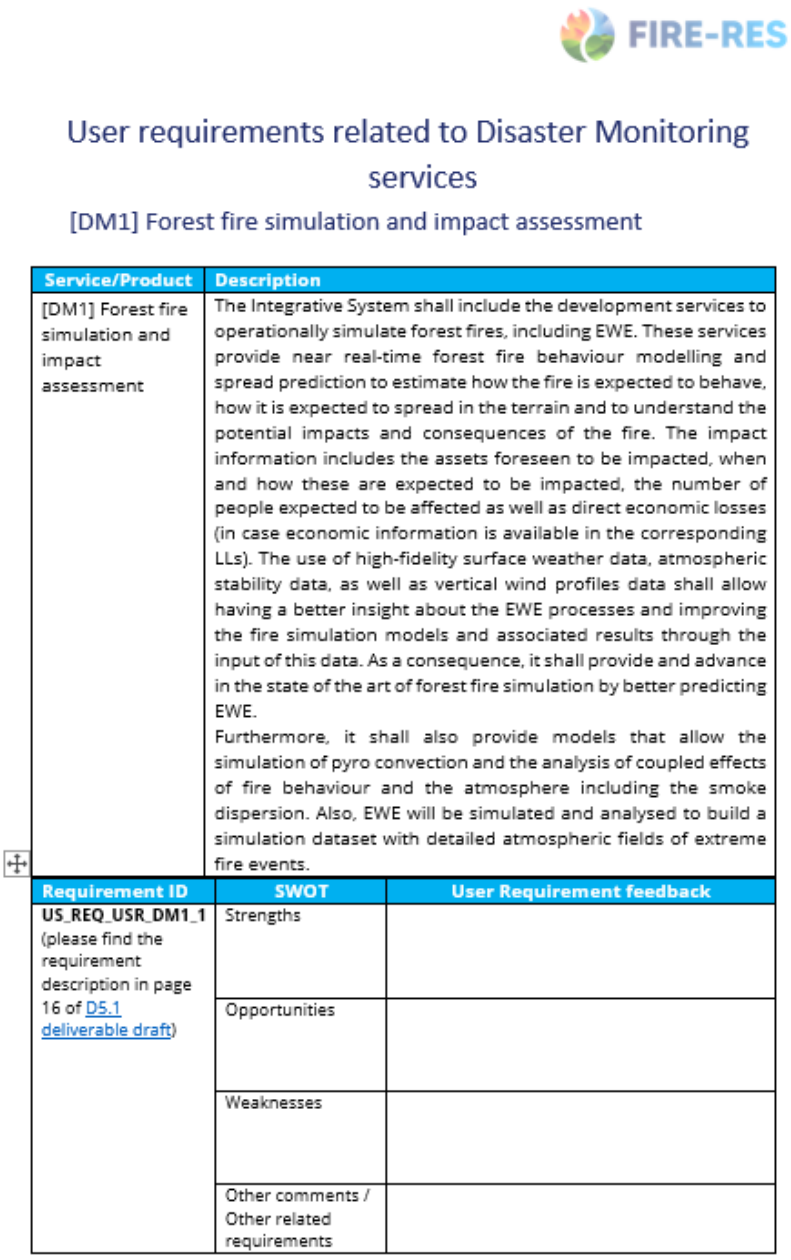
Description: This field includes the descriptive text of the requirement.

Notes: This field includes additional clarifications, restrictions or limitations to be taken into consideration in the definition of the requirement.

IA: Innovation Action numbering to which the requirement belongs to (if any IA).

The gathered requirements shall be taken as basis for the development of the Integrative System (i.e., in subtask 5.1.3.) as well as for the development of the several services and products in the corresponding WP5 tasks and subtasks.

Once completed, the technical user requirements have been shared with the partners in WP5 with an end-user profile which have reviewed the proposed technical requirements and provided their feedback on these. This has been carried out by the ANEPC, ENB, SFRS and XUNTA partners. In order to gather their feedback, end-user feedback collection forms have been prepared in advance and shared with these partners for this specific purpose. In this regard, the forms included a SWOT analysis to try to obtain their views regarding strengths, opportunities and weaknesses on the reviewed technical requirements with the aim of extracting as much feedback as possible. Figure 2 shows an example of the structure of such feedback-collection form:



FIRE-RES

User requirements related to Disaster Monitoring services

[DM1] Forest fire simulation and impact assessment

Service/Product	Description
[DM1] Forest fire simulation and impact assessment	The Integrative System shall include the development services to operationally simulate forest fires, including EWE. These services provide near real-time forest fire behaviour modelling and spread prediction to estimate how the fire is expected to behave, how it is expected to spread in the terrain and to understand the potential impacts and consequences of the fire. The impact information includes the assets foreseen to be impacted, when and how these are expected to be impacted, the number of people expected to be affected as well as direct economic losses (in case economic information is available in the corresponding LLs). The use of high-fidelity surface weather data, atmospheric stability data, as well as vertical wind profiles data shall allow having a better insight about the EWE processes and improving the fire simulation models and associated results through the input of this data. As a consequence, it shall provide and advance in the state of the art of forest fire simulation by better predicting EWE. Furthermore, it shall also provide models that allow the simulation of pyro convection and the analysis of coupled effects of fire behaviour and the atmosphere including the smoke dispersion. Also, EWE will be simulated and analysed to build a simulation dataset with detailed atmospheric fields of extreme fire events.

Requirement ID	SWOT	User Requirement feedback
US_REQ_USR_DM1_1 (please find the requirement description in page 16 of D5.1 deliverable draft)	Strengths	
	Opportunities	
	Weaknesses	
	Other comments / Other related requirements	

Figure 2 Example of one of the end-user feedback forms used to gather feedback on the requirements

Once these forms have been gathered these have been analysed and discussed among the partners whom proposed the technical user requirements. The analysis of the end-user reviews helped the partners that are going to integrate services and products into the Integrative System to fine-tune the requirements as well as to adjust the description of the products and services included in Section 4 of the present document.

5.1. Technical user requirements

The following sub-sections include the list of technical user requirements, organized by several categories, according to the application scenarios specified in Section 2. Besides the four described scenarios an additional category has been added to gather the general requirements of the Integrative System. In this regard the used categories, these are the following: i) General technical user requirements – Requirements that are related to the functionality of the system in general and that are not directly related with any specific thematic. ii) Requirements related to risk assessment. iii) Requirements related to disaster monitoring. iv) Requirements related to interoperability. v) Requirements related to landscape recovery.

5.1.1. General technical user requirements

Requirement ID.: US_REQ_USR_GE_1	
User(s): Main and secondary users	Service/product: N/A
Description:	Main and secondary users shall be able to login in the system to access the corresponding services and products according to their access rights.
Notes	-
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_2	
User(s): Main users	Service/product: N/A
Description:	Main users shall be able to use an intuitive GUI to access and use the offered functionalities.
Notes	-
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_3	
User(s): Main and secondary users	Service/product: N/A
Description:	Main and secondary users shall have access to products (e.g., maps, graphics, risk assessment results, weather data, etc...) that are created by the system on a periodical basis.

Notes	Example of products: Forest fire risk assessment results, weather data, smoke in situ sensors data, first responders' exposure values from personal sensors, VOCs ...; Access restrictions according to the type user may apply.
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_4	
User(s): Main and secondary users	Service/product: N/A
Description:	Main and secondary users shall have access to products (e.g., maps, graphics, risk assessment results, weather data, etc...) that are created by the system on demand.
Notes	The user may receive a notification once the product or service outcome is available. Access restrictions according to the user rights may apply.
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_5	
User(s): Main and secondary users	Service/product: N/A
Description:	Main and secondary users shall be able to receive notifications when new or updated products are made available by the system.
Notes	The channels to distribute the notification shall be decided during the implementation phase. Access restrictions according to the type user may apply.
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_6	
User(s): Main users	Service/product: N/A
Description:	Main users shall be able to configure parameters from the different services/applications affecting the functionality of these.

Notes	This requirement refers to parameters that affect single parts/services of the system and that might alter the obtained results.
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_7	
User(s): Main users	Service/product: N/A
Description:	The system administrator shall be able to create, edit and delete user accounts and add/remove the corresponding user access rights.
Notes	-
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_8	
User(s): Main users	Service/product: N/A
Description:	Main users shall be able to access and visualise data from external services (e.g., hotspots, weather data, GIS data, …)
Notes	The exact external services to be integrated shall be defined in task T5.2 and integrated in task T5.1.3.
IA	IA 5.1

Requirement ID.: US_REQ_USR_GE_9	
User(s): Main users	Service/product: N/A
Description:	Main users shall be able to export generated products (e.g., maps, risk assessment results, simulation results, graphs, …)
Notes	The format of the exported products may vary according to the product (formats such as, PDF, KMZ, GeoTIFF, …).
IA	IA 5.1

5.1.2. Technical user requirements related to risk assessment

Requirement ID.: US_REQ_USR_RA1_1	
User(s): Main and Secondary Users	Service/product: RA1
Description:	Main users and Secondary Users shall be able to access and visualise the daily forest fire risk assessment and fire behaviour results of the corresponding LL area.
Notes	The risk results shall be provided for several hours of the day (e.g., each 3h). The process of fire risk calculation should take into account the live fuel moisture content of the fuels. Risk metrics also related to the probability of occurrence of extreme fire phenomena such as pyrocumulus should be explored. Secondary users shall be able to download and/or visualise results.
IA	IA 5.2

Requirement ID.: US_REQ_USR_RA1_2	
User(s): Main and Secondary Users	Service/product: RA1
Description:	Main and Secondary Users shall be able to access and visualise the historical daily forest fire risk assessment and fire behaviour results of the LL area.
Notes	The risk results shall be provided for several hours of the day (e.g., each 3h). Secondary users shall be able to download and/or visualise results
IA	IA 5.2

Requirement ID.: US_REQ_USR_RA3_1	
User(s): Main and Secondary Users	Service/product: RA3
Description:	Main and secondary users shall be able to access and visualise the fuel maps derived from LiDAR Earth Observation data as well as time series evolution and metrics based on Live fuel moisture content over of the fixed LL areas.
Notes	Results shall include metrics of LIDAR and satellite datasets where LiDAR and satellite datasets would be available for the corresponding LL area.

IA	IA 5.3

Requirement ID.: US_REQ_USR_RA2_1	
User(s): Main and Secondary Users	Service/product: RA2
Description:	Main and Secondary Users shall be able to access and visualise the results of daily HR surface weather forecast for the corresponding LLs areas.
Notes	Also, historical HR surface weather data should be accessible to the users. Secondary users shall be able to download and/or visualise results of daily HR surface weather forecast for the corresponding LLs areas.
IA	IA 5.2

Requirement ID.: US_REQ_USR_RA4_1	
User(s): Main and Secondary users	Service/product: RA4
Description:	Main and Secondary Users shall be able to access and visualize the results of periodical maps of the concentration of flammable volatiles for the corresponding LLs areas.
Notes	The period of map production is still to be defined. Secondary users shall be able to download and/or visualise VOCs maps results.
IA	IA 5.2

5.1.3. Technical user requirements related to disaster monitoring

Requirement ID.: US_REQ_USR_DM1_1	
User(s): Main Users	Service/product: DM1
Description:	The user shall be able to simulate in an operational time frame the behaviour and progression of forest fires including EWE.
Notes	The simulation shall allow the use of HR surface weather and vertical atmospheric weather profiles.

	The simulation tool should be able to take into account the crown fire phenomena as well as fire spotting. The simulation may be calibrated from observed perimeter, so that fire suppression actions can be taken into action in case they influence fire propagation and are observed. The results should be analysed by a specific fire analyst.
IA	IA 5.2

Requirement ID.: US_REQ_USR_DM1_2	
User(s): Main Users	Service/product: DM1
Description:	The user shall be able to visualise the results of the operational simulation of the behaviour and progression of forest fires including EWE.
Notes	Also access to historical simulation results shall be possible. The results should be analysed by a specific fire analyst.
IA	IA 5.2

Requirement ID.: US_REQ_USR_DM1_3	
User(s): Main Users	Service/product: DM1
Description:	The user shall be able to visualise the impact analysis results of the operational simulation of the behaviour and progression of forest fires including EWE.
Notes	Impact analysis results may include, size of affected area, population, buildings and economic affectation in the case this base data is provided by the corresponding LLs.
IA	IA 5.2

Requirement ID.: US_REQ_USR_DM1_4	
User(s): Main Users	Service/product: DM1
Description:	The user shall be able to trigger operational full fire/atmosphere simulation behaviour and progression of forest fires including EWE (only one per day maximum – remote on a supercomputer).

Notes	Fire simulation may be restarted from observed perimeter, so that fire suppression action can be taken into action if they influence fire propagation and in case these are observed. Experimental developments for torching and spotting will be tested in the latest version of the product. Simulations performed as prototype on Univ-Corsica Supercomputer, access may not be secured. The results should be analysed by a specific fire analyst.
IA	IA 5.2

Requirement ID.: US_REQ_USR_DM1_5	
User(s): Main users	Service/product: DM1
Description	The user shall be able to visualize the results of fire/atmosphere high resolution fire simulation, potential pyro convection and fire effect on local weather forecast.
Notes	Results are foreseen to be delivered as several video stream and ground smoke impact map.
IA	IA 5.2

Requirement ID.: US_REQ_USR_DM2_1	
User(s): Main Users	Service/product: DM2
Description:	The user shall be able to simulate the smoke plume progression forecasts together with the smoke compounds concentration.
Notes	Inputs are smoke source term (composition, emission rate, plume height, etc.) and meteorological drivers.
IA	IA 5.7

Requirement ID.: US_REQ_USR_DM2_2	
User(s): Main Users	Service/product: DM2
Description:	The user shall be able to visualise the results of the operational simulation of the smoke plume progression forecasts together with the smoke compounds concentration.

Notes	Specific concentration thresholds should be considered and clearly depicted to alert for dangerous concentration for population and first responders.
IA	IA 5.7

Requirement ID.: US_REQ_USR_DM3_1	
User(s): Main Users	Service/product: DM3
Description:	The user shall be able to visualise the main atmospheric vertical weather forecast information that would impact the behaviour and progression of forest fires including EWE.
Notes	This data shall also be used as input to the operational forest fire simulator (including EWE).
IA	IA 5.5

Requirement ID.: US_REQ_USR_DM4_1	
User(s): Main Users	Service/product: DM4
Description:	Main users (i.e., First Responders) shall be able to make use of INESC TEC wearable devices (physiological patch for vital data and small environmental box for personal weather data) providing hands-free information of health and exposure data to the operation command centre.
Notes	This information is aimed to be used in real-time, but it can and should also be used in post-mission reports and team management in term of shifts and teams' rotations on fire suppression operations. In the case of real-time information, the command centre shall have access to the information in a dashboard showing specific information about each firefighter (physiological and environmental).
IA	IA5.7

Requirement ID.: US_REQ_USR_DM4_2	
User(s): Main Users	Service/product: DM4
Description:	Main Users (i.e., First Responders) shall be able to obtain the weather conditions in the surroundings of their firefighting engines.

Notes	This information is aimed to be used in real-time, but it can and should also be used in post-mission reports and team management in terms of shifts and teams' rotations on fire suppression operations. In the case of real-time information, the command centre shall have access to the information in a dashboard showing specific information about each firefighter/engine surrounding weather data.
IA	IA5.7

Requirement ID.: US_REQ_USR_DM4_3	
User(s): Main Users	Service/product: DM4
Description:	Main Users (i.e., First Responders) shall be able to monitor the dispended water during fire-fighting operations.
Notes	This information is aimed to be used in real-time, but it can and should also be used in post-mission reports and team management in terms of shifts and teams' rotations on fire suppression operations. In the case of real-time information, the command centre shall have access to the information in a dashboard specific information about the firefighting engines dispended water.
IA	IA5.7

Requirement ID.: US_REQ_USR_DM4_4	
User(s): Main Users	Service/product: DM4
Description:	The Main Users (i.e., First Responders) shall be able to visualize on a map the estimation of the location of the fire line, see the previous locations and future estimations.
Notes	The command centre shall have access to the information in a dashboard showing the location of the fire line, its past and future predicted location.
IA	IA5.7

Requirement ID.: US_REQ_USR_DM4_5	
User(s): Main Users	Service/product: DM4

Description:	The Main Users (i.e., First Responders) shall be able to visualize the geolocation of the firefighters' teams on the field.
Notes	This information is aimed to be used in real-time, but it can and should also be used in post-mission reports and team management in term of shifts and teams' rotations on fire suppression operations.
IA	IA5.7

Requirement ID.: US_REQ_USR_DM5_1	
User(s): Main Users	Service/product: DM5
Description:	Main users (i.e., First Responders) shall be able to visualise the exposure of first responders to several air pollutants (PM2.5, BC) in real time as well as biometric variables (e.g., heart rate).
Notes	-
IA	IA5.7

5.1.4. Technical user requirements related to interoperability in sharing forest fire data

Requirement ID.: US_REQ_USR_IN1_1	
User(s): Main user	Service/product: IN1
Description:	Main users shall be able to use a GIS data-exchange solution to facilitate the monitoring and management of EWE by stakeholders over the world in a specific region with an EWE spreading.
Notes	A linkage solution shall be provided to get access to the Responders GIS data. The solution is intended to be used by fire analysts.
IA	IA 5.9

Requirement ID.: US_REQ_USR_IN1_2	
User(s): Main users	Service/product: IN1

Description:	Main users shall be able to access forest fire data shared by other emergency agencies and shall be able to share their own data with other emergency agencies.
Notes	The format of the shared data may vary according to the type of data. A way to communicate and share data could be through the use of online cartographic platforms, this shall be explored in the specification and development of the interoperability services.
IA	IA5.9

5.1.5. Technical user requirements related to landscape recovery

Requirement ID.: US_REQ_USR_LR1_1	
User(s): Main and Secondary Users	Service/product: LR1
Description:	Main and Secondary users shall be able to access and visualise the land cover changes over vegetation categories results of the LL area.
Notes	Results shall include metrics about the main patterns and directions of change at temporal and spatial dimensions at the corresponding LL area. Secondary users shall be able to download and/or visualise results.
IA	IA 5.3

Requirement ID.: US_REQ_USR_LR2_1	
User(s): Main and Secondary Users	Service/product: LR2
Description:	Main and Secondary users shall be able to access and visualise the severity maps time series evolution and metrics over types of land covers results of the LL area. Secondary users shall be able to download and/or visualise results.
Notes	As far as possible, impact analysis results shall include results dealing with the CO2eq emitted.
IA	IA 5.3

Requirement ID.: US_REQ_USR_LR3_1	
User(s): Main and Secondary Users	Service/product: LR3
Description:	Main and Secondary Users shall be able to access and visualise Forest cover restoration and adaptation maps of the LL area. Secondary users shall be able to download and/or visualise results.
Notes	As far as possible, LiDAR metrics about morphology of the forests and changes will be analysed
IA	IA 5.3

6. Integrative system architecture

In FIRE-RES the Integrative System shall integrate and provide access to services and products for Main Users (MU) such as first responders, command and control centres and forest managers in charge of dealing with forest fire incidents and the management of the forests. It shall be able to also address Secondary Users (SU) such as educational and research institutions or the general public. The several services and products planned to be integrated and made accessible through the Integrative System have been described in Section 4 of this document. This chapter of the document presents the system architecture that has as main aim allowing offering and demonstrating the mentioned services and products in the corresponding LLs in FIRE-RES. The presented setup shows a local unit that would provide the functionalities to a single authority/entity. Data sharing is addressed in a two-fold way, related to a local unit it would allow sharing the system data inside the same organization, allowing sharing specific data among different user groups inside the same entity such as first responders and command and control centres. Furthermore, some specific products shall be able to be shared with Secondary Users such as academic/research institutions and the population as well as accessing and sharing specific GIS data with other agencies from other, regions or countries. The latter shall be possible through the interconnection through a dedicated content-oriented data sharing channel. This allows a federated architecture where certain forest fires related data can be shared among different organizations allowing and improving interoperability among several agencies. The exact data to be accessed and shared, as well as the sharing procedure shall be defined in the framework of Task 5.5. “Improvement of interoperability among international stakeholders”.

6.1. The architecture approach

The Integrative System architecture shall follow a modular approach through the use of microservices (i.e., as far the implementation allows) with the aim of providing implementation flexibility as well as functional and operational scalability. A functional scalability allows adapting the functionalities to be provided while the operational scalability allows the adaptability of the system to the existing organizational structures and systems. In the first case it presents the benefits that it allows a modular deployment, tailored to each given situation, by integrating only the elected modules/services without this affecting the general architecture. Due to its flexibility, it would also allow adding other modules/services in the future, if these would become available. Through the use of standardized interfaces as far as possible, the Integrative System would allow the addition of new services or modules such as additional input sources or modules that would provide further functionalities. Regarding the operational scalability, it presents the benefit of being able to address a wide range of situations such as different organizational and geographical structures.

In this regard, a modular architecture approach should allow an easier deployment and integration of the services and products integrated throughout the project with future potential clients' emergency management systems and services. In this regard it aims also to facilitate the commercialization of the system and/or of its services and products.

The mentioned architecture approach also permits a distributed system implementation by allowing the installation of the several modules and services in different geographical locations. This type of implementation does not affect the access to the services and increases the resiliency of the system since it is less likely that all the distributed locations are affected by a hypothetical technical issue.

6.2. Local Unit architecture

Considering all the aspects mentioned in the previous subsection, Figure 3 presents the overall high-level architecture of the Integrative System, following the mentioned modular micro services approach. The diagram shows the several modules that are planned to be integrated, the necessary interfaces among the modules as well as among these and the users of the services/products. In that regard, as specified in Section 3, the users of the services/products are categorised into two main categories, i.e., main users and secondary users.

Primary users are planned to access the services and products by using a dedicated graphical user interface (GUI) from their computers, laptops or mobile devices. The access to the several services and products shall depend on their access rights that can be configured individually.

Secondary users shall not have direct access to the services and products and therefore a dedicated GUI is not planned for their use. They shall be able to access/fetch and download the files made available by the Integrative System through a dedicated web service.

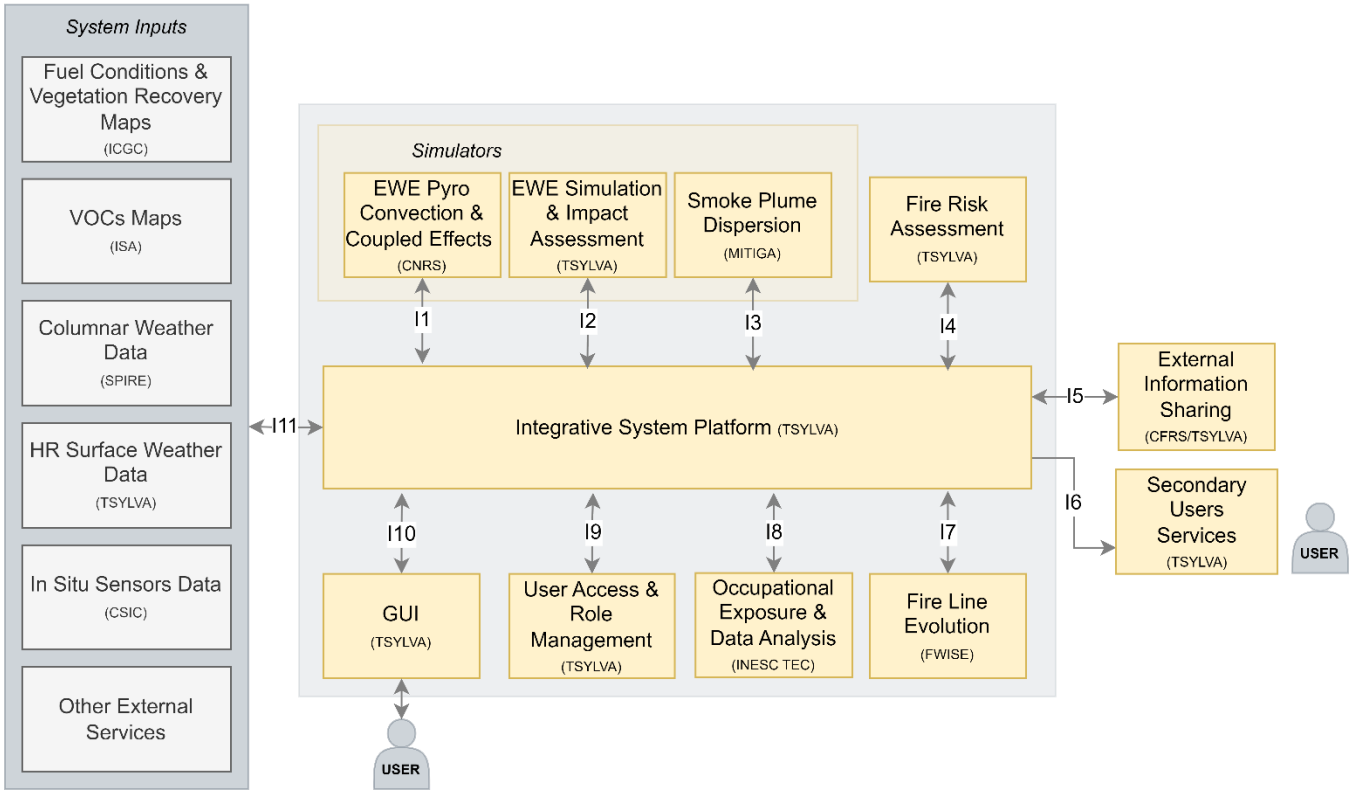


Figure 3 Integrative System Architecture Diagram

As can be observed in Figure 3, on the left-hand side of the diagram the System Inputs including inputs and pre-prepared products are presented, the related interfaces communications and expected functionalities are specified in Section 6.3.11. These products and services are part of the work description within several tasks of WP5. The simulators shown in the upper centre part of the diagram which interfaces are described correspondingly in Sections 0, 0, and 0 include the several planned simulation technologies foreseen in WP5 workplan description, i.e., simulation of forest fires (including EWE) and associated impact assessment of the fire developed in the framework of task 5.3.1., a smoke plume dispersion simulator developed in the framework of task 5.3.2. and a high-detail EWE simulator that simulates the pyro convection processes and fire-atmosphere coupled effects of the fire developed also within task 5.3.1. To the right of the "simulators" box we find the "Fire Risk Assessment" module that generates through the use of HPC resources and high-resolution surface weather the periodical risk metrics for the addressed LLs areas. The interfaces communications are described in Section 0. On the right-hand side of the diagram the external information sharing channel is presented. The related interfaces communications are presented in Section 0. Through this channel agencies shall be able to access and interchange relevant data and information related to EWE (e.g., GIS data) and below it the Secondary Users Services

access channel. In the lower central part of the diagram are shown the Graphical User Interface (interfaces communications are described in Section 6.3.8), the user Access & role management module (interfaces communications described in Section 0), the occupational exposure and related data analysis module (interfaces communications described in Section 0) as well as the Fire Line Evolution tool are shown (interfaces communications described in Section 6.3.6).

For the sake of clarity, in the diagram of Figure 3 the interfaces (i.e., I1-I11) are combined, each single interface displayed in the diagram represents a set of interfaces sharing information between the corresponding two end-points (e.g., I1, I2, I3, …). Nevertheless, all the communications are done between the modules and the Integrative System Platform (ISP), therefore a single connection between the corresponding module and the ISP can represent the mentioned communication methods. The interfaces and functionalities of each module are specified in Section 6.3.

6.3. Integrative System modules

This section presents the several modules of the planned Integrative System architecture, providing an overall description of each module, a diagram presenting its high-level interfaces, and a high-level definition of the information foreseen to be shared among the interfaces and a list of the foreseen functionalities. In this section only the interconnected modules/services as well as the nature of the data is exchanged (excluding plain data requests).

6.3.1. Integrative System Platform

The ISP shall work as a central hub for the entire system, allowing the connection of the several models and the sharing of data flows among the several integrated modules. With this aim, it exposes interfaces mainly based on web technologies and open standards allowing the several modules to publish and fetch data according to the predefined workflows and interfaces. It offers a data repository for geo-referenced data (i.e., vector and raster), sensor data as well other types of data where it can be stored and acquired on-demand. It allows modules to push and pull information asynchronously and facilitates the connection of heterogeneous services, thus promoting the scalability of the system.

Furthermore, the ISP includes a workflow engine that orchestrates the several integrated modules by invoking them and performing multiple operations according to the predefined workflows fluxes and establishes communication methods.

Finally, the ISP provides dedicated interfaces to connect to external service providers to fetch information from external sources. It also can expose output products through an interface to be consumed/operated by secondary users.

As can be observed in Figure 4, the ISP interfaces with practically all main components modules of the system. The corresponding diagram shows the interconnections of the ISP in the architecture.

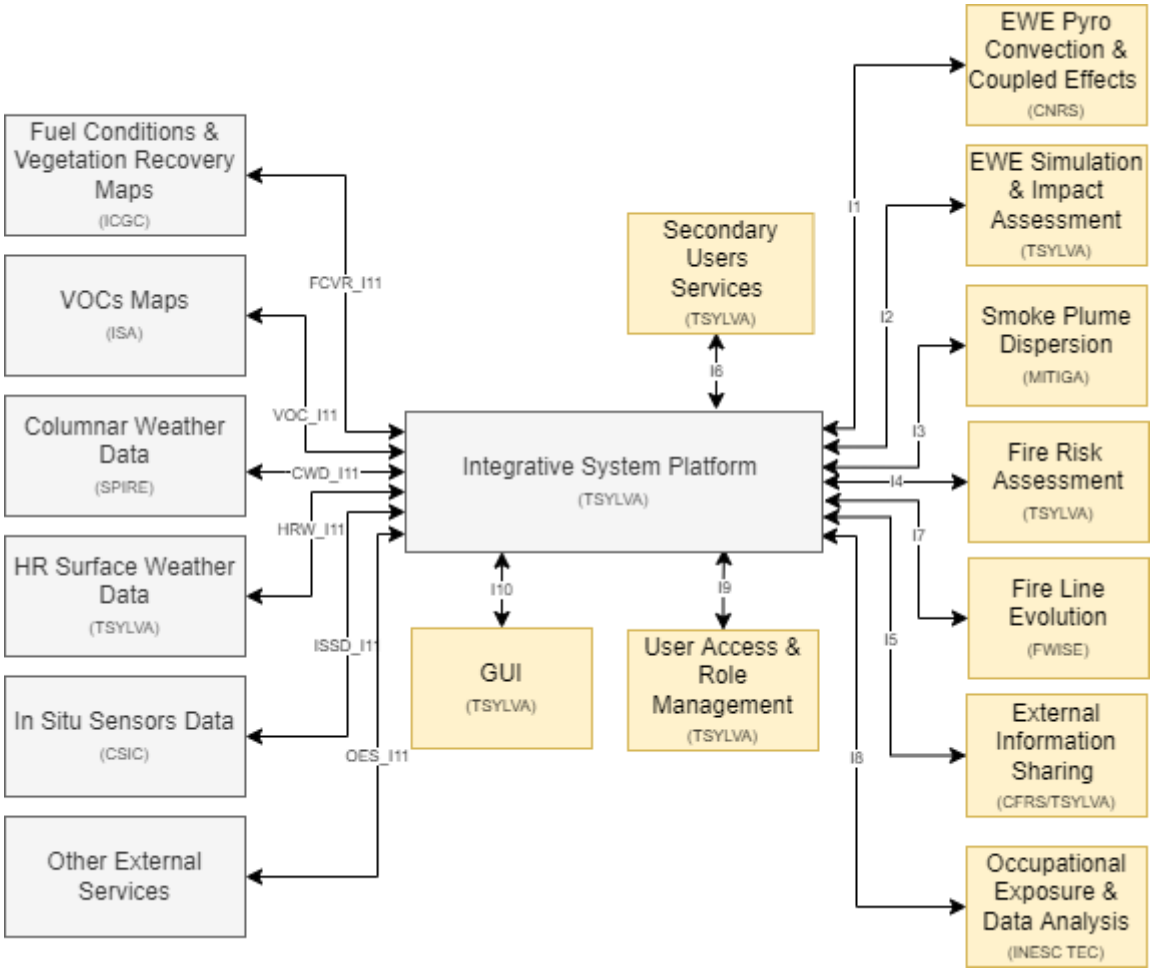


Figure 4 The Integrative System Platform within the Integrative System architecture

The corresponding interfaces and the information shared among these are defined in Section 6.3 from Subsection 6.3.1 to 6.3.11.

The main functionalities provided by the Integrative System Platform are listed in Table 4.

Table 4 Functionalities to be provided by the Integrative System Platform

Functionality	Description	Related requirements
FUN_ISP_1	**Support User Access Control** (through user account)	US_REQ_USR_GE_1 US_REQ_USR_GE_7
FUN_ISP_2	**Support authorization and encryption** (For all the interconnected modules)	N/A
FUN_ISP_3	**Implement a modular architecture to allow scalability and expandability**	N/A
FUN_ISP_4	**Interface with external services for data acquisition** Data such as weather data, GIS data, …	US_REQ_USR_GE_8
FUN_ISP_5	**Enable invocation of interconnected services according to workflows** (manually or automatically triggered)	N/A
FUN_ISP_6	**Allow data acquisition and storage** (Plain data and geo-referenced data)	N/A
FUN_ISP_7	**Expose interfaces for sensor data communication**	US_REQ_USR_DM5_1
FUN_ISP_8	**Support multiple active incidents at the same time** (allow linking stored and published data with a given incident)	N/A
FUN_ISP_9	**Interface with "Fuel conditions & Vegetation recovery" maps services** To obtain the corresponding maps	US_REQ_USR_RA3_1 US_REQ_USR_LR1_1 US_REQ_USR_LR2_1 US_REQ_USR_LR3_1
FUN_ISP_10	**Interface with "VOCs" maps service** To obtain the corresponding maps and data	US_REQ_USR_RA4_1
FUN_ISP_11	**Interface with "Columnar weather data" services** To obtain the corresponding vertical atmospheric weather data	US_REQ_USR_DM3_1
FUN_ISP_12	**Interface with "HR weather data" service**	US_REQ_USR_RA2_1

	To obtain the corresponding surface level weather data	
FUN_ISP_13	**Interface with "EWE Pyro Convection & Coupled Effects" services** To communicate data, parameters and receive simulation results	US_REQ_USR_DM1_4 US_REQ_USR_DM1_5
FUN_ISP_14	**Interface with "EWE simulation & impact assessment" services** To communicate data, parameters and access simulation results	US_REQ_USR_DM1_1 US_REQ_USR_DM1_2 US_REQ_USR_DM1_3
FUN_ISP_15	**Interface with "Smoke Plume Dispersion" services** To communicate data, parameters and receive simulation results	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2
FUN_ISP_16	**Interface with "Fire Risk Assessment" services** To communicate data and receive risk results	US_REQ_USR_RA1_1 US_REQ_USR_RA1_2
FUN_ISP_17	**Interface with "Fire line evolution" services** To communicate data and receive fire line location results	US_REQ_USR_DM4_4
FUN_ISP_18	**Provide interface to exchange GIS data with other fire agencies** To send and receive fire management related GIS data	US_REQ_USR_IN1_1 US_REQ_USR_IN1_2
FUN_ISP_19	**Interface with "Occupational exposure and data analysis" services** To communicate data, parameters and receive results	US_REQ_USR_DM4_1 US_REQ_USR_DM4_2 US_REQ_USR_DM4_3 US_REQ_USR_DM4_4 US_REQ_USR_DM4_5
FUN_ISP_20	**Provide a web service for the provision of system products to secondary users** (third parties)	N/A

6.3.2. EWE Simulation and Impact Assessment

The EWE simulation and impact assessment services will be developed and provided by TSYLVA. These services are in charge of performing operational forest fire behaviour simulations (including EWE) triggered by the user by setting an initial fire line/ignition point, date, and associated simulation parameters. These estimations are performed

based on terrain, vegetation fuels (including fuel moisture data), HR surface weather and atmospheric columnar weather data. It also performs an operational analysis of the estimated impacts on existing assets, population and economy (in case this impact base data is available in the LLs). The expected fire behaviour and impact outputs are presented to the user through the GUI. Some of the outputs may be used by the operational Smoke Plume Dispersion simulator as inputs to perform the smoke dispersion analysis. As can be observed in Figure 5, the EWE simulation and Impact Assessment services interface with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

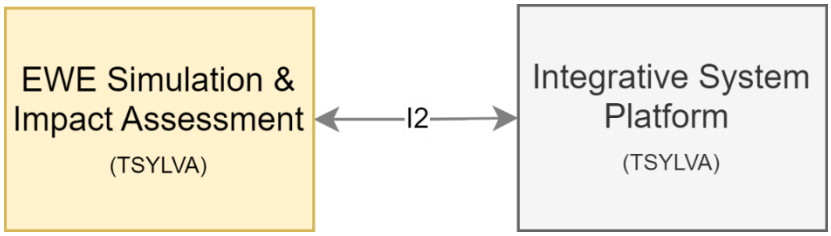


Figure 5 The EWE Simulation and Impact Assessment services within the Integrative System architecture

The main Interface communications of the EWE Simulation and Impact Assessment services are presented in Table 5.

Table 5 I2 interface information exchange

Interface	I2
Module/ Services interfaces	• EWE Simulation and Impact Assessment (SIM) • Integrative System Platform (ISP)
Information exchanged	From SIM to ISP: • Simulation outputs (raster, vector data) • Impact Assessment results (JSON) From ISP to SIM: • Simulation requests & parameters • HR surface weather data • Atmospheric columnar weather data

The main functionalities provided by the EWE Simulation and Impact Assessment services are listed in Table 6.

Table 6 Functionalities provided by the EWE Simulation and Impact Assessment services

Functionality	Description	Related requirements
FUN_SIM_1	**Simulate and display on a map the outputs of spread and behaviour of the fire (including EWE)** The simulations shall be triggered manually by the user	US_REQ_USR_DM1_1 US_REQ_USR_DM1_2 US_REQ_USR_DM1_3
FUN_SIM_2	**Adjust fire (including EWE) spread simulations based on new observations of the fire conditions on the field.** The user may be able to manually adjust the simulation based on their own knowledge about the real conditions of the fire on the field. This shall allow taking into account the effect of the suppression activities by the resources on the field.	US_REQ_USR_DM1_1 US_REQ_USR_DM1_2 US_REQ_USR_DM1_3
FUN_SIM_3	**Save simulation results**	US_REQ_USR_DM1_1 US_REQ_USR_DM1_2 US_REQ_USR_DM1_3
FUN_SIM_4	**Load simulation results**	US_REQ_USR_DM1_1 US_REQ_USR_DM1_2 US_REQ_USR_DM1_3
FUN_SIM_5	***Estimate and display the impacted buildings, population and economic values*** *The analysis of impacted assets (buildings), population and economic values depends on the availability of data*	US_REQ_USR_DM1_3

6.3.3. EWE Pyro Convection and Coupled Effects

The EWE pyro convection and Coupled Effects module to be developed and provided by CNRS shall be activated only for a forest fire that is already ongoing and that has been identified by the user as having a high potential of EWE (only one simulation a day is possible). It is triggered manually by the user from a selected reference state (a starting location or contour with an associated hour/date) from which the coupled simulation shall be started. Boundary atmospheric conditions is foreseen to be taken from the ECMWF 0Z forecast. 10 hours of fire propagation is expected to be able to provide the simulation outputs 5 hours after initialization and 24 hours of simulated forecasts is expected to be able to provide outputs 8 hours after the initialisation of the simulation.

These simulations will also compute, with an atmospheric model, the coupled effect between wind/convection/fire/smoke in 3 dimensions, with high computational and data cost, but able to simulate potential fire driven gusts, and PyroConvection up to PyroCb and smoke tracer. Some of the outputs may be used by the operational Smoke Plume Dispersion simulator to compare results.

As can be observed in Figure 6, the EWE Pyro Convection and Coupled Effects services interface with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

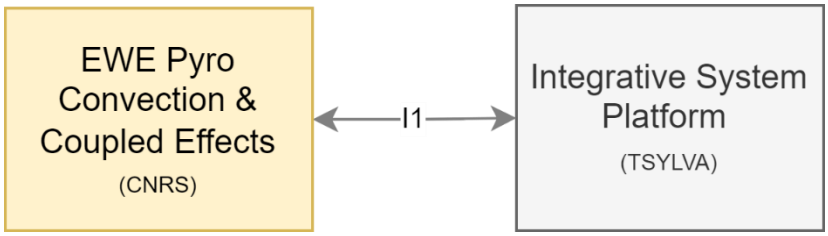


Figure 6 The EWE Pyro Convection and Coupled Effects services within the Integrative System architecture

The main Interface communications of the EWE Pyro Convection and Coupled Effects services are presented in Table 7.

Table 7 I3 interface information exchange

Interface	I3
Module/ Services interfaces	• EWE pyro convection and coupled effects (SIM_ATM) • Integrative System Platform (ISP)
Information exchanged	From SIM_ATM to ISP: • Simulation outputs (raster of arrival time, wind grids, smoke) • Animated video of cloud formation and high energy wind dynamics From ISP to SIM_ATM: • Simulation requests • Date and initial fire-line geometry with the associated georeferentiation coordinates

The main functionalities provided by the EWE Pyro Convection and Coupled Effects services are listed in Table 8.

Table 8 Functionalities provided by the EWE Pyro Convection and Coupled Effects service

Functionality	Description	Related requirements
FUN_SIM_ATM_1	**Simulate and display on a map the outputs of spread, surface winds and smoke concentration on a 50km/50km domain (including EWE)** The simulations shall be triggered manually by the user from a FUN_SIM_1 ignition geometry (i.e., ignition point/line with an associated time).	US_REQ_USR_DM1_4 US_REQ_USR_DM1_5
FUN_SIM_ ATM_2	**Provide animated visualisation of the simulation.** A 3D animation of the simulation at high temporal evolution, showing a potential view (wind, clouds) of what may happen in fire/atmosphere interaction.	US_REQ_USR_DM1_5

6.3.4. Smoke Plume Dispersion Model

The Smoke Plume Dispersion (SPD) simulation service developed and provided by MITIGA shall perform operational forest fire smoke plume dispersion simulations (including EWE) triggered automatically by the ISP just after an operational fire spread simulation is finished. The service communicates with the ISP and uses as inputs the Fire Spread model outputs (from the EWE simulation service; Section 6.3.2), the smoke source term (composition, emission rate, plume height, etc) and the weather data as a driver. In addition to the SPD model outputs, this same service shall provide to the ISP, hazardous smoke compounds' concentration maps and warnings when risk thresholds are exceeded to be displayed to the user through the GUI.

As can be observed in Figure 7, the Smoke Plume Dispersion services interface directly with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

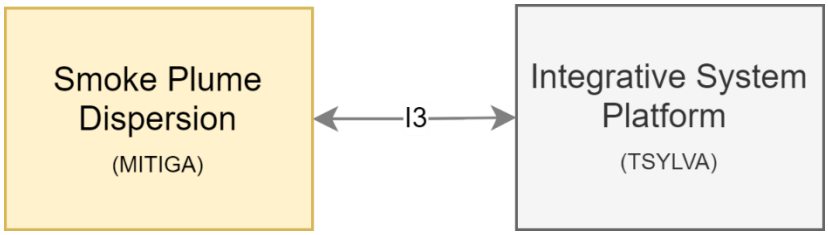


Figure 7 The Smoke Plume Dispersion services within the Integrative System architecture

The main Interface communications of the Smoke Plume Dispersion services are presented in Table 9.

Table 9 I3 interface information exchange between the Smoke Plume Dispersion services and the ISP

Interface	I3
Module/ Services interfaces	• Smoke Plume Dispersion (SPD) • Integrative System Platform (ISP)
Information exchanged	From SPD to ISP: • Simulation outputs (raster data in netCDF format) • Smoke constituents' concentration maps (PNG, PDF, ...) From ISP to SPD: • Simulation request • VOCs data • EWE Fire simulation outputs • Weather data (HR when available)

The main functionalities provided by the Smoke Plume Dispersion services are listed in Table 10.

Table 10 Functionalities provided by the Smoke Plume Dispersion services

Functionality	**Description**	**Related requirements**
FUN_SPD_1	**Simulate the dispersion of the smoke plume.** The simulations shall be triggered by the system once the fire behaviour simulations finish	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2
FUN_SPD_2	**Create concentration maps from the Smoke Plume Dispersion model outputs.** The different smoke compounds, heights and concentrations ranges to display	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2

	should be pre-agreed with other work package partners.	
FUN_SPD_3	**Produce concentrations warnings and alerts according to predefined thresholds**	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2
FUN_SPD_4	**Save simulation results**	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2
FUN_SPD_5	**Load simulation results**	US_REQ_USR_DM2_1 US_REQ_USR_DM2_2

6.3.5. Fire risk Assessment

The fire risk assessment module to be developed and provided by TSYLVA provides periodically, i.e., daily forest fire risk assessment in the corresponding LLs areas by performing in dedicated HPC resources thousands of fire behaviour simulations with the forecasted HR weather data. The results of these simulations are then aggregated to obtain several fire risk and fire behaviour metrics for the several hours of the day.

The Fire Risk Assessment module shall make use of vegetation fuel models (including fuel moisture values), DEM base data that shall be directly integrated in the application and shall make use of the HR weather data to be provided through the ISP to the module.

As can be observed in Figure 8, the Fire Risk Assessment services interface directly with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

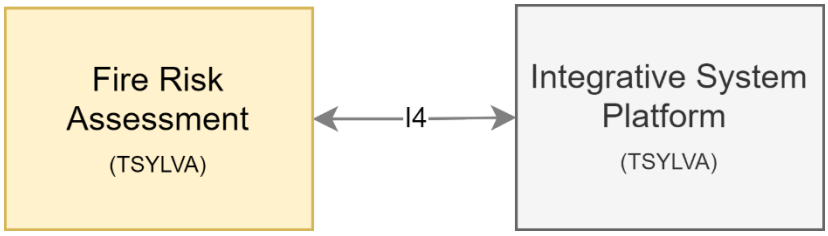


Figure 8 Fire Risk Assessment services within the Integrative System architecture

The main interface communications of the Fire Risk Assessment services are presented in Table 11.

Table 11 I4 interface information exchange

Interface	I4
Module/ Services interfaces	• Fire Risk Assessment (FRA) • Integrative System Platform (ISP)
Information exchanged	From FRA to ISP: • Fire risk outputs (raster data)

	From ISP to FRA: • HR surface weather forecast data

The main functionalities provided by the Fire Risk Assessment services are listed in Table 12.

Table 12 Functionalities provided by the Fire Risk Assessment services

Functionality	Description	Related requirements
FUN_FRA_1	**Calculate on a periodical basis and show on a map the assessment of forest fire risk results/metrics for the next few days** The fire risk assessment shall be triggered periodically by the system	US_REQ_USR_RA1_1
FUN_FRA_2	**Select and load fire risk results for the selected time frame of the day**	US_REQ_USR_RA1_2
FUN_FRA_3	**Export fire risk results in GeoTIFF and/or KMZ**	US_REQ_USR_GE_9

6.3.6. Fire Line Evolution

This service to be developed and provided by FWISE aims to take advantage of the data that is collected in the "Occupational Exposure and Data Analysis" module (see Section 6.3.7.) to design a new method to assess the fire line evolution based only on variables that are being collected by the system on the field, namely using the geolocation of all First Responders team members, wind speed, direction and water dispended.

This system will make use of the "Occupational Exposure and Data Analysis" API to retrieve the data from the WeSENSS system (please see Section 6.3.7), process it using the developed models and store in WeSENSS database the results to be retrieved by the ISP. This shall facilitate the communication between systems because it shall not increase the number of modules, making use of the same API.

As can be observed in Figure 9, the Fire Line Evolution services interface directly with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

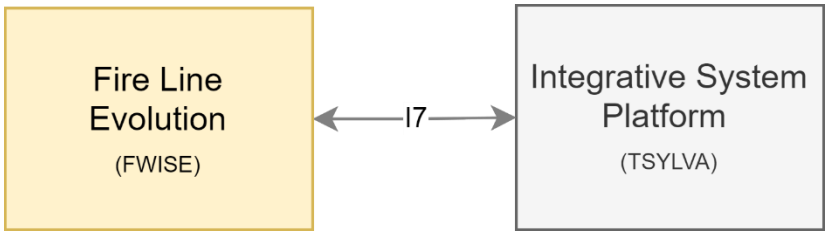


Figure 9 Fire Line Evolution services within the Integrative System architecture

The main interface communications of the Fire Line Evolution services are presented in Table 13.

Table 13 I7 interface information exchange

Interface	I7
Module/ Services interfaces	• Fire Line Evolution (FLE) • Integrative System Platform (ISP)
Information exchanged	From FLE to ISP: • Fireline geographic coordinates to be displayed in the GUI (along the fire suppression session or for debriefing sessions/report) From ISP to FLE: • Data requests

The main functionalities provided by the Fire Line Evolution services are listed in Table 14.

Table 14 Functionalities provided by the Fire Line Evolution services

Functionality	**Description**	**Related requirements**
FUN_FLE_1	**Real-time information of the fire-line location and progression**	US_REQ_USR_DM4_4
FUN_FLE_2	**Estimation of the future direction and progression of the fire-line** This shall be done only based on data collected from the field in real-time by the first responders	US_REQ_USR_DM4_4

6.3.7. Occupational Exposure and Data Analysis

INESC TEC has been developing the WeSENSS technology that is a IoT wearable and mobile-based system that interconnects different systems to collect valuable data on the field during fire suppression. This data includes physiological and environmental data

from each first responder individually and other types of data concerning the firefighting engines. For this, INESC TEC shall make use of proprietary wearable devices, mobile systems that share information with the main server and an analytic engine to process some of this data with a focus on occupational health analysis and share it with third-party systems. All this information is shared making use of a RESTful API and notifications making use of Google Firebase system. The ISP will work as a third-party system which will request data to INESC TEC WeSENSS server making use of the corresponding RESTful API. A full list of variables that will be retrieved from the ISP will be provided during the implementation phase jointly with the API documentation for the integration of the services in the Integrative System.

As can be observed in Figure 10, the Occupational Exposure & Data Analysis (OEDA) services interface directly with the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

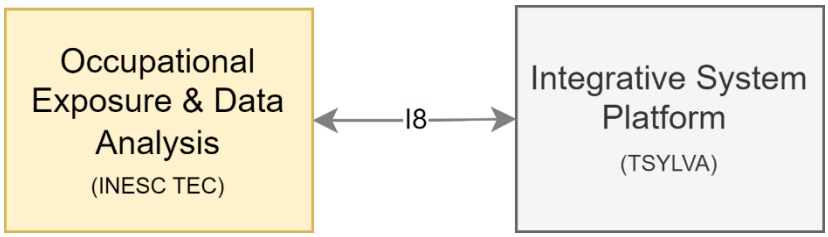


Figure 10 Occupational Exposure & Data Analysis services within the Integrative System architecture

The main interface communications of the Occupational Exposure & Data Analysis services are presented in Table 15.

Table 15 I8 Interface information exchange

Interface	I8
Module/ Services interfaces	• Occupational Exposure & Data Analysis (OEDA) • Integrative System Platform (ISP)
Information exchanged	From OEDA to ISP: • First responder data: physiological-ECG, heart rate, skin temperature, position, movement, respiration; environmental: temperature, humidity, CO, VOCs, atmospheric pressure, particles (PM2.5, PM10). • Firefighting engines data: location, wind speed, direction, amount of rain, temperature,

	humidity, CO, VOCs, atmospheric pressure, particles (PM2.5, PM10), water expended. From ISP to OEDA: • Data requests • Creation of events and association of the firefighters (teams) that are going to be monitored in a specific place and time. • Creation of users' profile that are going to be monitored

The main functionalities provided by the Occupational Exposure & Data Analysis services are listed in Table 16.

Table 16 Functionalities provided by the Occupational Exposure & Data Analysis services

Functionality	Description	Related requirements
FUN_OEDA_1	**Provide the health and exposure status of each first responder in real-time**	US_REQ_USR_DM4_1
FUN_OEDA_2	**Provide the location of the first responders and fire trucks/ fire suppression engines**	US_REQ_USR_DM4_5
FUN_OEDA_3	**Provide the water consumption of the fire suppression engines**	US_REQ_USR_DM4_3
FUN_OEDA_4	**Provide local weather data surrounding the fire suppression engines**	US_REQ_USR_DM4_2

6.3.8. Graphical User Interface

The Graphical User Interface (GUI) provides the users access to the functionalities of the Integrative System as well as provides access to the functionalities of the several services and products to be integrated by developing and making use of a user interface (e.g., web portal). Furthermore, the GUI shall be intuitive and easy to use by the users to allow them to easily access and use the different components and functionalities made accessible by the Integrative System.

As can be observed in Figure 11, the GUI interfaces the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

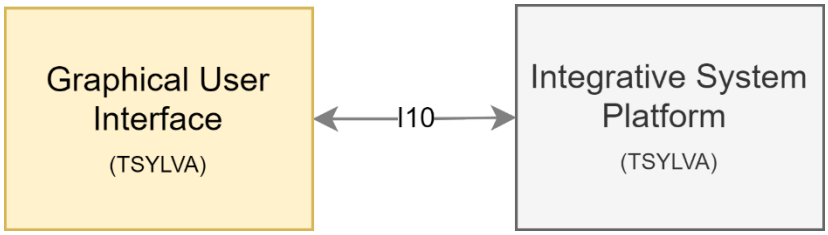


Figure 11 The GUI within the Integrative System architecture

The main interface communications of the GUI are presented in Table 17.

Table 17 I10 interface information exchange

Interface	I10
Module/ Services interfaces	• Graphical User Interface (GUI) • Integrative System Platform (ISP)
Information exchanged	From GUI to ISP: • EWE Simulation requests • EWE Pyro convection and coupled effects requests • Smoke Plume dispersion simulation requests • Fire Risk Assessment requests • Fireline evolution requests • Weather data requests • Occupational exposure and data analysis requests • External information sharing requests • Maps products requests • In situ sensor data requests From ISP to GUI: • EWE Simulation results • EWE Pyro convection and coupled effects results • Smoke Plume dispersion simulation results • Fire Risk Assessment results • Fireline evolution results • Weather data results • Occupational exposure and data analysis results • Maps products results

	• In situ sensor data results • External Information Sharing results

The main functionalities provided by the GUI are listed in Table 18.

Table 18 Functionalities provided by the GUI

Functionality	Description	Related requirements
FUN_GUI_1	**Integrate the functionalities of the modules on the GUI**	US_REQ_USR_GE_2 US_REQ_USR_GE_3 US_REQ_USR_GE_4 US_REQ_USR_GE_5 US_REQ_USR_GE_6 US_REQ_USR_GE_8 US_REQ_USR_GE_9 US_REQ_USR_IN1_2

6.3.9. User Access and Role Management

The User Access and Role Management (UARM) module has a twofold purpose, it offers a login interface that allows the identification of the user and their access to the functionalities according to their user rights. It provides also the interface for a system administrator to create, delete and manage user accounts and provide several access permissions. As can be seen in Figure 12 the User and Role Management module interfaces with the ISP through which the several communications flow.

As can be observed in Figure 12, the UARM interfaces the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

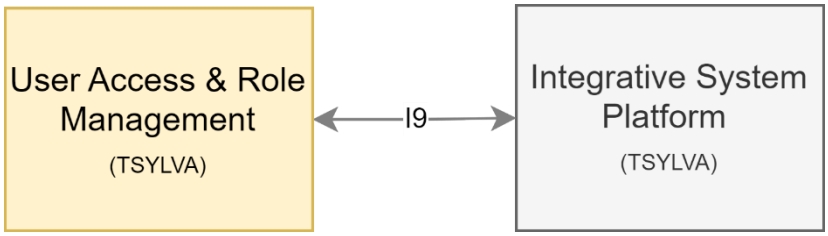


Figure 12 The User Access & Role Management within the Integrative System architecture

The main interface communications of the UARM are presented in Table 19.

Table 19 I9 interface information exchange

Interface	I9
Module/ Services interfaces	• User Access and Role Management (UARM) • Integrative System Platform (ISP)
Information exchanged	From UARM to ISP: • Active role of the user • A valid token, in the case a token-based method is used From ISP to UARM: • Valid user login credentials (from GUI)

The main functionalities provided by the UARM are listed in Table 20.

Table 20 Functionalities provided by the User Access and Role Management

Functionality	**Description**	**Related requirements**
FUN_UARM_1	**Allow the administrator to create accounts and give different access permissions to users. The administrator shall also be able to delete accounts.**	US_REQ_USR_GE_1 US_REQ_USR_GE_7
FUN_UARM_2	**Provide user access control (through user account).**	US_REQ_USR_GE_1 US_REQ_USR_GE_7

6.3.10. External Information Sharing

The main purpose of this External Information Sharing (EIS) service is to share the platform's information with other external users and agencies. This action should be carried out practically in real time. With this service it would be possible to both transfer information to other agencies and to receive information from them.

This information needs to be on a format that will allow to be integrated on the data management systems of the majority of the externals end-users.

As can be observed in Figure 13, the EIS interfaces the ISP. The corresponding diagram shows the interconnections of the services in the architecture.

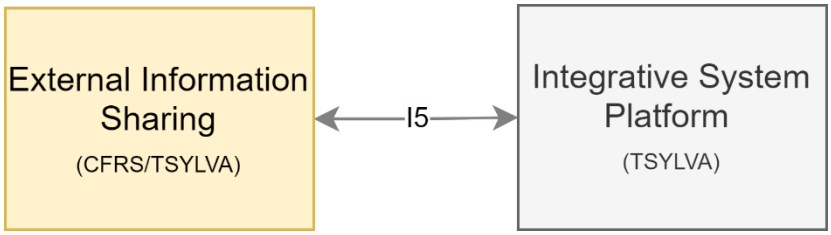


Figure 13 External Information Sharing Services within the Integrative System architecture

The main interface communications of the EIS are presented in Table 21.

Table 21 I5 Interface information exchange

Interface	I5
Module/ Services interfaces	• External Information Sharing (EIS) • Integrative System Platform (ISP)
Information exchanged	From EIS to ISP: • EWE key data • Real on-site Meteorological data From ISP to EIS: • EWE fire behaviour metrics • EWE extension, perimeter • EWE atmospheric data

The main functionalities provided by the EIS are listed in Table 22.

Table 22 Functionalities provided by the Occupational Exposure & Data Analysis services

Functionality	**Description**	**Related technical requirements**
FUN_EIS_1	**Allow the ISP to incorporate new data provided by external users**	US_REQ_USR_IN1_1 US_REQ_USR_IN1_2
FUN_EIS_2	**Allow the internal users share their data to an external user or agency**	US_REQ_USR_IN1_1 US_REQ_USR_IN1_2

6.3.11. Integrative System Inputs

The Integrative System shall integrate multiple sub-systems or modules that provide data to the System with several purposes. In this regard, depending on the data it can be used to be simply visualised in the GUI or it can be forwarded to the integrated services to be used by these as input data. These data vary from pre-prepared map products, weather data, VOCs concentrations data, sensor data from sensors located on the field as well as external services. The latter shall provide additional data and services to the Integrative System.

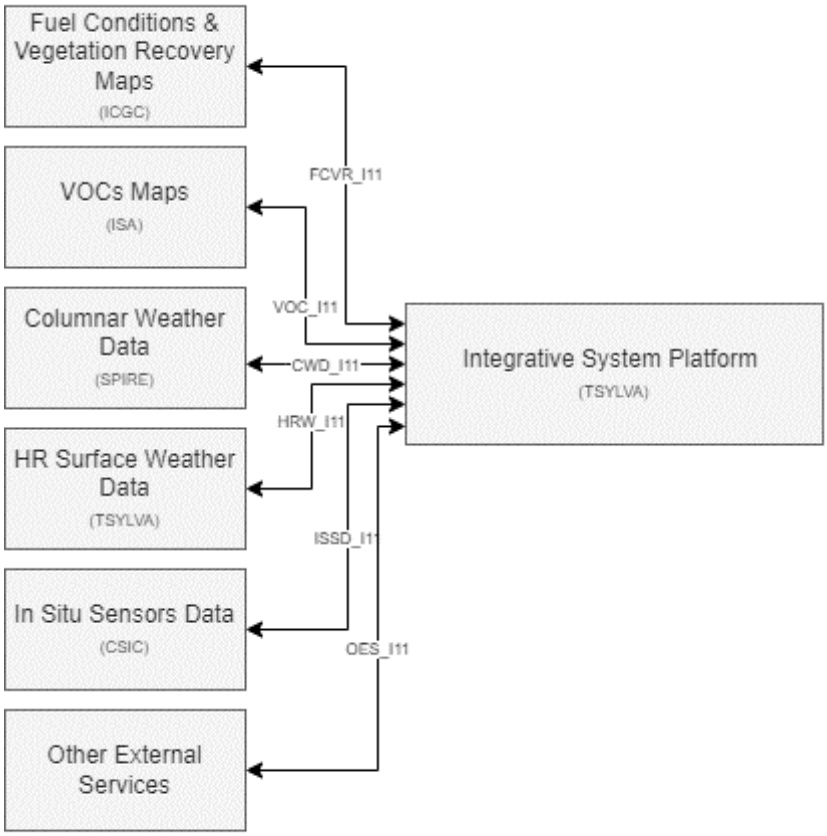


Figure 14 System inputs and their interface with the Integrative System Platform

Each of these sub-systems is foreseen to be connected to the Integrative System Platform through a dedicated service, however for the sake of clarity these are represented in Figure 14 with a single interface (I11). Figure 4 from Section 6.3.1 provides further details about the individual interfaces. Each of the sub-systems and associated interfaces are explained hereinafter in the following sub-sections.

6.3.11.1. Columnar weather data

The global columnar weather data (CWD) will be provided by Spire's global forecast model that is powered by over 15.000 radio occultation profiles collected by their satellites.

The CWD data will be offered as global GRIB2 files. The forecast is split into several small files, each containing the forecast for one specific time of the forecast (lead time), for one isobaric level (i.e., 500 hPa). Alternatively, Spire offers a few predefined regions to limit the scope of data, and in this case each file will be limited to that specific region.

The files can be downloaded using a simple to use API, that allows listing all available forecast files and downloading them. An API documentation will be provided for the technical teams when the implementation is about to be started.

The main interface communications of the CWD are presented in Table 23.

Table 23 CWD_I11 Interface information exchange

Interface	CWD_I11
Module/ Services interfaces	• Columnar Weather Data (CWD) • Integrative System Platform (ISP)
Information exchanged	From CWD to ISP: • Current Atmospheric Columnar Weather conditions • Atmospheric Columnar Weather conditions forecasts From ISP to CWD: • Data requests

6.3.11.2. High-Resolution Weather Data

The high-resolution surface weather forecast (HRW) module shall create and provide high-fidelity weather data to the Integrative System through the ISP interface. This data includes current HR weather data, HR weather forecast data and potentially also historical weather data (e.g., for past fires reanalysis). This data is foreseen to be visualised by the users for their analysis and to be consumed by other modules of the System such as the "Risk Assessment", the "Smoke Plume Dispersion" and the "EWE Simulation & Impact Assessment". The main interface communications of the HRW are presented in Table 24.

Table 24 HRW_I11 Interface information exchange

Interface	HRW_I11
Module/ Services interfaces	• High-Resolution Weather Data (HRW) • Integrative System Platform (ISP)
Information exchanged	From HRW to ISP: • Current High-Resolution Surface Weather • High-Resolution Surface Weather Forecasts • Historical High-Resolution Surface Weather

6.3.11.3. Fuel conditions and vegetation recovery maps

Fuel conditions and vegetation recovery (FCVR) maps will be provided to the ISP periodically based on the availability of earth observation data from COPERNICUS Data. Fuel conditions will be reported as a set of different indexes based on spectral

performances of COPERNICUS optical satellites as well as additional information such as land cover, ground truth or LIDAR coverages in case of these would be suitable at the Living Labs. On the same assumptions recovery maps will be based in principle, on severity indexes. The Integrative System GUI should be capable to show and allow the analysis by the users of time series of metrics and parameters associated to FCVR time evolution.

The main interface communications of the FCVR are presented in Table 25.

Table 25 FCVR_I11 Interface information exchange

Interface	FCVR_I11
Module/ Services interfaces	• Fuel Conditions and Vegetation Recovery maps (FCVR) • Integrative System Platform (ISP)
Information exchanged	From FCVR to ISP: • Fuel Conditions maps (periodically updated) • Vegetation Recovery maps (periodically updated)

6.3.11.4. VOCs maps

Concentration of Flammable Volatiles (VOCs), such as CO and α-pinene, will be collected by ISA using Sentinel-5 satellite (TROPOMI spectrometer) data [1]. ISA is still evaluating the VOCs to be considered, and the frequency of map data production. This will be decided in a meeting between TSYLVA, ISA, and Nova University [2]. The VOCs data shall be provided to the ISP through a dedicated interface.

The main interface communications of the VOC services are presented in Table 26.

Table 26 VOC_I11 Interface information exchange

Interface	VOC_I11
Module/ Services interfaces	• Concentration of Flammable Volatiles (VOCs) • Integrative System Platform (ISP)
Information exchanged	From VOCs to ISP: • Maps of Concentration of Flammable Volatiles (periodically updated) • Data of concentration of Flammable Volatiles (periodically updated)

6.3.11.5. In Situ Sensors Data

Air pollutant exposure metrics (PM2.5 and BC) and biometrical data (heart rate) will be collected using portable sensors by CSIC. CSIC is still evaluating two alternatives to integrate the in-situ sensor data to the ISP: i) submitting data via a dedicated API or storing and enabling access via the ISP. This will be decided before the end of 2022.

The main interface communications of the In Situ Sensors data services are presented in Table 27.

Table 27 ISSD_I11 Interface information exchange

Interface	ISSD_I11
Module/ Services interfaces	• In Situ Sensors Data (ISSD) • Integrative System Platform (ISP)
Information exchanged	From ISSD to ISP: • First responders' biometrical data (heart rate) • Air quality metrics from portable sensors on the field (PM2.5 and BC)

6.3.11.6. Other External Services

Apart from the data and products provided by the several modules that shall be interfacing the Integrative System, the ISP is foreseen to be connected to several external Services from which the System obtains data and services that provide added value to the Main Users or that provide data or services that are needed by the modules to generate the corresponding results. In this regard, the ISP shall implement service-specific interfaces that shall retrieve the information from the external service provider by making use of the specific service provider's API, adapt it and embed it to the ISP. The services to be integrated are part of the discussions of task "5.2. Acquisition and integration of data from internal and external sources". In this subsection are included the services that have been considered to be useful to be integrated following the discussions held with the partners that are going to provide the several modules to be integrated. In that sense, Table 28 presents the to date candidate external services and/or data that could be integrated during the implementation phase (i.e., development of the Integrative System). Further services may be identified during this phase to be integrated. The exact implementation process of these services shall be defined and carried out during the implementation phase of the Integrative System.

Table 28 External services and products that can be integrated into the Integrative System

External Services and/or products	**Description**
Copernicus Emergency Management Service (EMS) [3]	Integration of services from the European Forest Fire Information System (EFFIS) [7] that provides historical and near real-time data on forest fires. Several products can be integrated e.g., near real-time hotspot data in European territory.
Copernicus Atmosphere Monitoring Service (CAMS) [4]	Enhanced atmospheric environmental information available as forecasts, analyses and re-analysis.
European Centre for Medium-Range Weather Forecasts (ECMWF) [5]	ECMWF weather forecast data. This data could potentially be used by the ISP fire and smoke simulation services.
NOAA Global Forecast System (GFS) [6]	The Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP) [8]. Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration. This data could potentially be used by the ISP fire and smoke simulation services.
Cartographic data	Various layers including, geography, administrative, satellite imagery, roads, etc.

7. Conclusions

This report provided the documentation of the work carried out in subtask "5.1.1 Technical requirements" and subtask "5.1.2 System architecture". This work shall be used as basis for the development of subtask "5.1.3. Demonstration of an integrative system for estimating EWE risk and impact in real time with HR weather data (IA 5.1)", where the Integrative System specified in this document shall be developed and the integration of the several services, products and data to be part of the system shall take place. In order to put these developments and integration works in practice, close collaboration and communication between the developers of the Integrative System and those of the several services and products to be provided in several tasks of WP5 is expected. This joint work aims at successfully achieve the demonstration of the corresponding IAs covered by the several services and technologies in the corresponding LLs.

As has been mentioned in the document, the main purpose of the Integrative System in FIRE-RES is to provide a mean of allowing the several technological solutions mentioned throughout the present document to be demonstrated in the corresponding LLs. The Integrative System does not aim to create a new emergency management system nor to supersede any existing emergency system. Its modular architecture aims nevertheless to facilitate the implementation of the described WP5 services and products to be demonstrated in the several LLs, as well as to set a flexible modular development and integration. This modular approach is expected to be carried out in a way that facilitates the potential integration of the technological solutions into already existing end-user's emergency management Systems in the future (i.e., after the end of the project), having the final aim of further complementing already existing functionalities or tools. This is expected to be accomplished through the mentioned modular approach, as well as through the use of standardised interface communication protocols and data formats as far as possible.

8. References

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