FONDAZIONE links

PASSION FOR INNOVATION

# Algoritmi di Intelligenza Artificiale a Supporto della Gestione Emergenziale

CLAUDIO ROSSI

PROGRAM MANAGER

AI 4 INDUSTRY & SECURITY

# LINKS Foundation

LINKS FOUNDATION IS AN INSTRUMENTAL BODY OF **COMPAGNIA DI SAN PAOLO** AND OPERATES AS AN INSTRUMENTAL BODY OF **POLITECNICO DI TORINO**

LINKS Foundation, a central node of the Turin research and innovation ecosystem, operates in a consolidated international network with the aim of **contributing to technological and socio-economic progress through cutting edge applied research projects.**

**160+**
RESEARCHERS

**1º**
CONTRIBUTION/RESEARCHERS
Source: Based on European Commission data

**8º**
IN ITALY FOR EU FUNDED PROJECTS (H2020)
Source: European Commission.
Total assessed entities (research organizations): 263

**900+**
INDUSTRIAL PARTNERS

**17M €**
BILANCIO 2020

**1600+**
PUBLICATIONS

**24**
PATENT FAMILIES

# Artificial Intelligence, Data and Space

## A multidisciplinary group of researchers focused on getting value from the whole data value chain

The research domain focuses on the realization of **intelligent digital applications** capable of addressing the key challenges associated with **industrial and societal needs** coupling both the use of Artificial Intelligence and Data, often received from **satellites systems**. It operates with a holistic data-driven approach that **spans over the whole data chain across several domains.** Our final goal is to bridge the gap between R&D of products/services, supporting the growth of companies and territories towards a sustainable innovation that can create an impact on the society

### KEY COMPETENCES

- AI 4 PEOPLE
- GNSS & SPACE APPLICATIONS
- AI 4 INDUSTRY & SECURITY
- AI 4 GEO

### KEY PROGRAMMES

- ARTIFICIAL INTELLIGENCE
- SPACE TECHNOLOGIES
- DATA ENGINEERING
- UX & SERVICE DESIGN

**25+**

**PEOPLE**

34 average age

**2.4+ €M**

**YEARLY BUDGET**

78% EU
7% Commercial
15% Other
+50% Over 2014

**200+**

**24 countries**

**PARTNERS**

56% Companies
24% Research
8% Public
12% Other

**100+**

**PROJECTS**

20 EU Funded
44 Commercial
17 Other
7 Coordinated

### STRATEGIC PARTNERS

Microsoft, ENGINEERING, OSPEDALE SAN RAFFAELE, rcs, JRC EUROPEAN COMMISSION, Guala Closures Group, BDV BIG DATA VALUE ASSOCIATION, SIE, ERTICO ITS EUROPE

# Key Competences

## ARTIFICIAL INTELLIGENCE

- **Machine & Deep Learning**
- Unsupervised learning
- Federated Learning
- **Natural Language Understanding**
- Incremental & Transfer Learning
- Reinforcement Learning
- Embedded AI
- Natural Language Generation
- Ethics and Explainable AI
- Behavioral Analysis

## DATA ENGINERING

- Hybrid & Federated Arch.
- **Big Data Architectures**
- Business Intelligence
- Full stack prototyping
- IoT & Wearable
- Recommender Systems
- **Crowdsourcing**
- Interoperability & Linked Data
- Synthetic Dataset for AI
- **Heterogenous Data Fusion**

## SPACE TECHNOLOGIES

- **Galileo, Copernicus & GovSat**
- **Data & Signal processing**
- Hybridization of Space & Terrestrial Tech
- **Satellite-based downstream application**
- Software Defined Radio (SDR)

## UX AND SERVICE DESIGN

- **Human Centered Design**
- Co-design
- Gamification
- User-data interaction

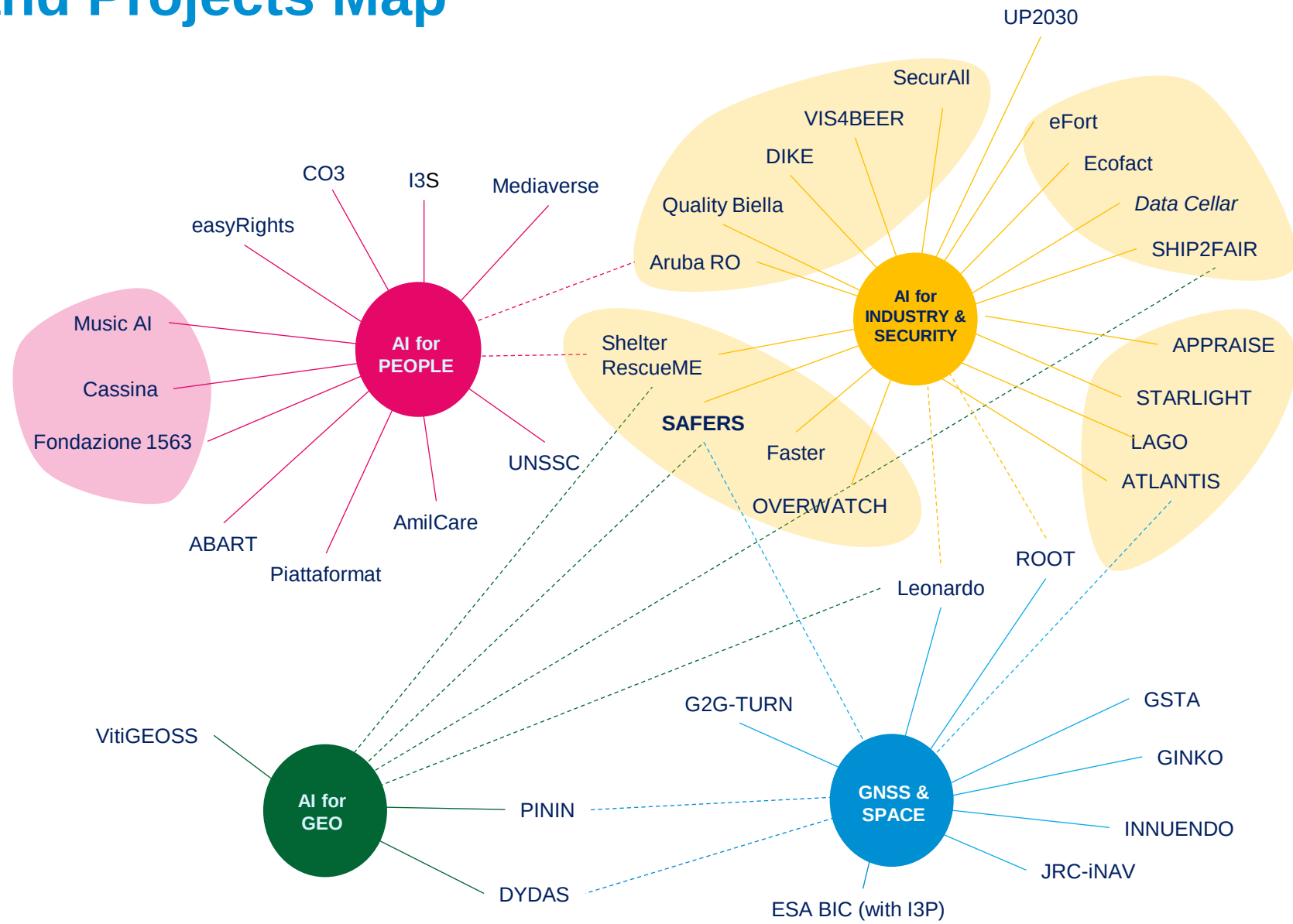
# Strategic Programs and Projects Map

**AI FOR PEOPLE**
*Health, Wellbeing, Culture, Tourism, Creativity, Inclusive Society*

**AI for INDUSTRY & SECURITY**
*Security (People & Infrastructures), Disaster Resilience, Digital Industry, Energy, Mobility*

**GNSS & SPACE APPLICATIONS**
*Galileo, Copernicus, LEO, AI for Signal Analysis*

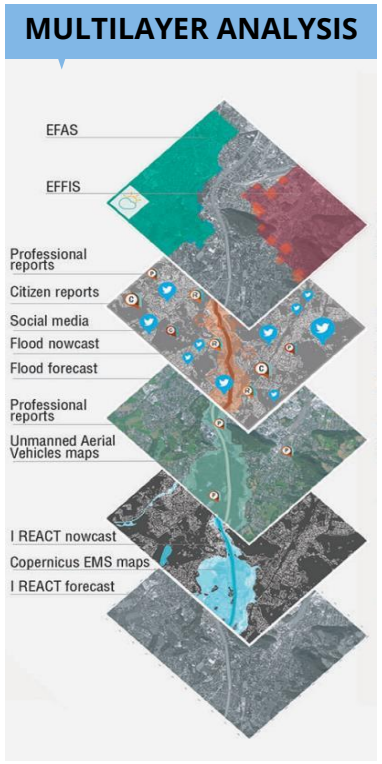
**AI for GEO**
*Climate, Environment, Food & Agritech, Geospatial Applications*



# AI for Industry & Security

Overview of the program

Exploit heterogeneous data sources to create **intelligent tools** and **services** to solve **industrial** and **societal challenges**, including the fight against natural hazards and man-made disasters**.**




Example: I-REACT project

**Research topics**:
- Natural Language Processing (NLP)
- Image analysis from multiple sources
  - Geospatial
  - In-situ
  - Drones
- Time series analysis

**Impact areas**:
- Disaster Risk Reduction
- Public Safety
- Energy
- Agriculture

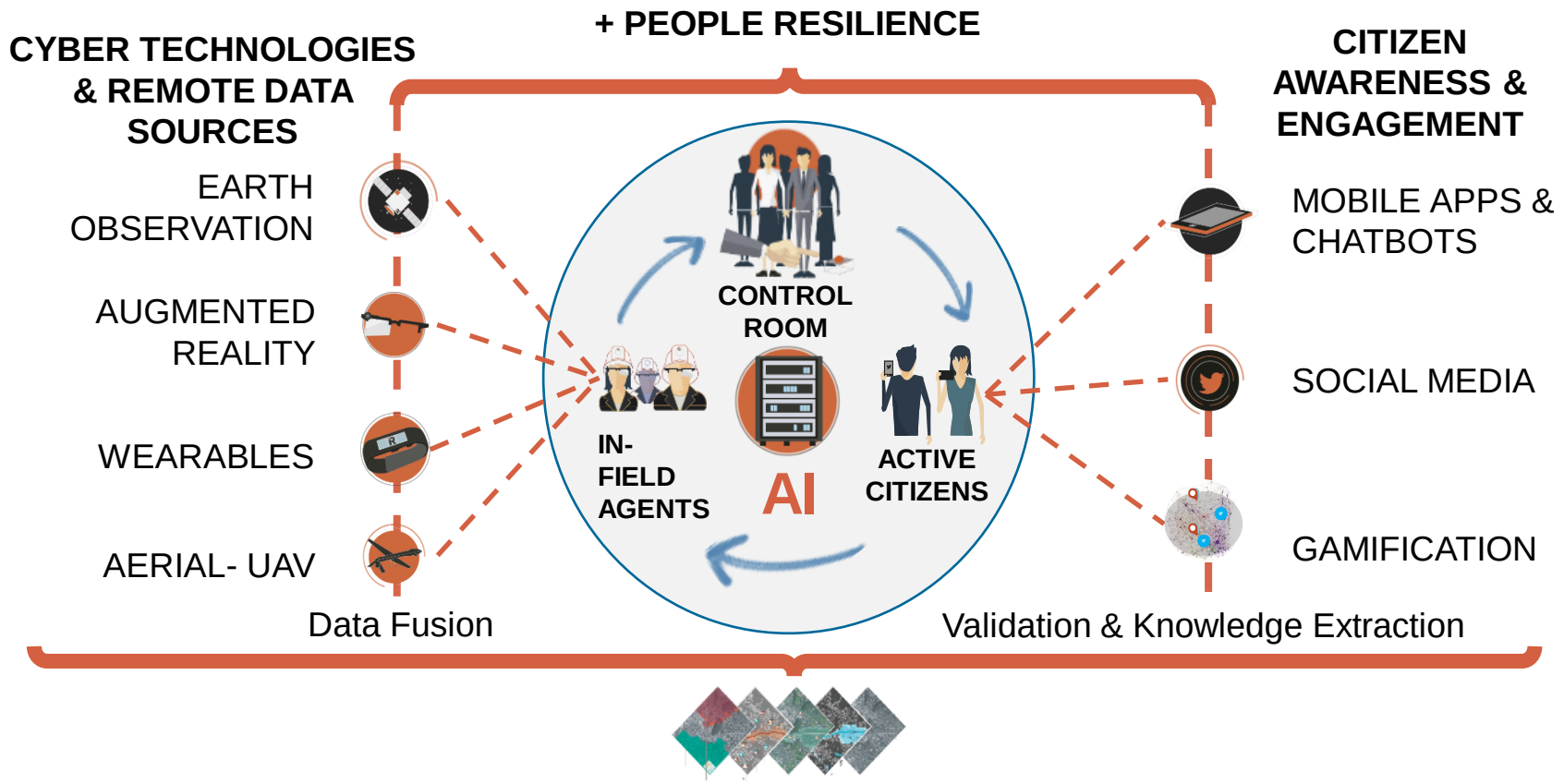
**Flagship projects**:
- SAFERS (H2020) - **coordinated**
- SHELTER (H2020) – leadership
- DATA CELLAR (H2020) – leadership
- APPRAISE/STARLIGHT (H2020)

**Current active projects**: 19
**Researchers**: 20+
**Publications**: 40+

**Working groups**
- Big Data Value Association (now DAIRO)
- Euro GEO
- Community for European Research and Innovation for Security (CERIS)

# ERMES - Enhancing Resiliency to Manage Emergency Situations

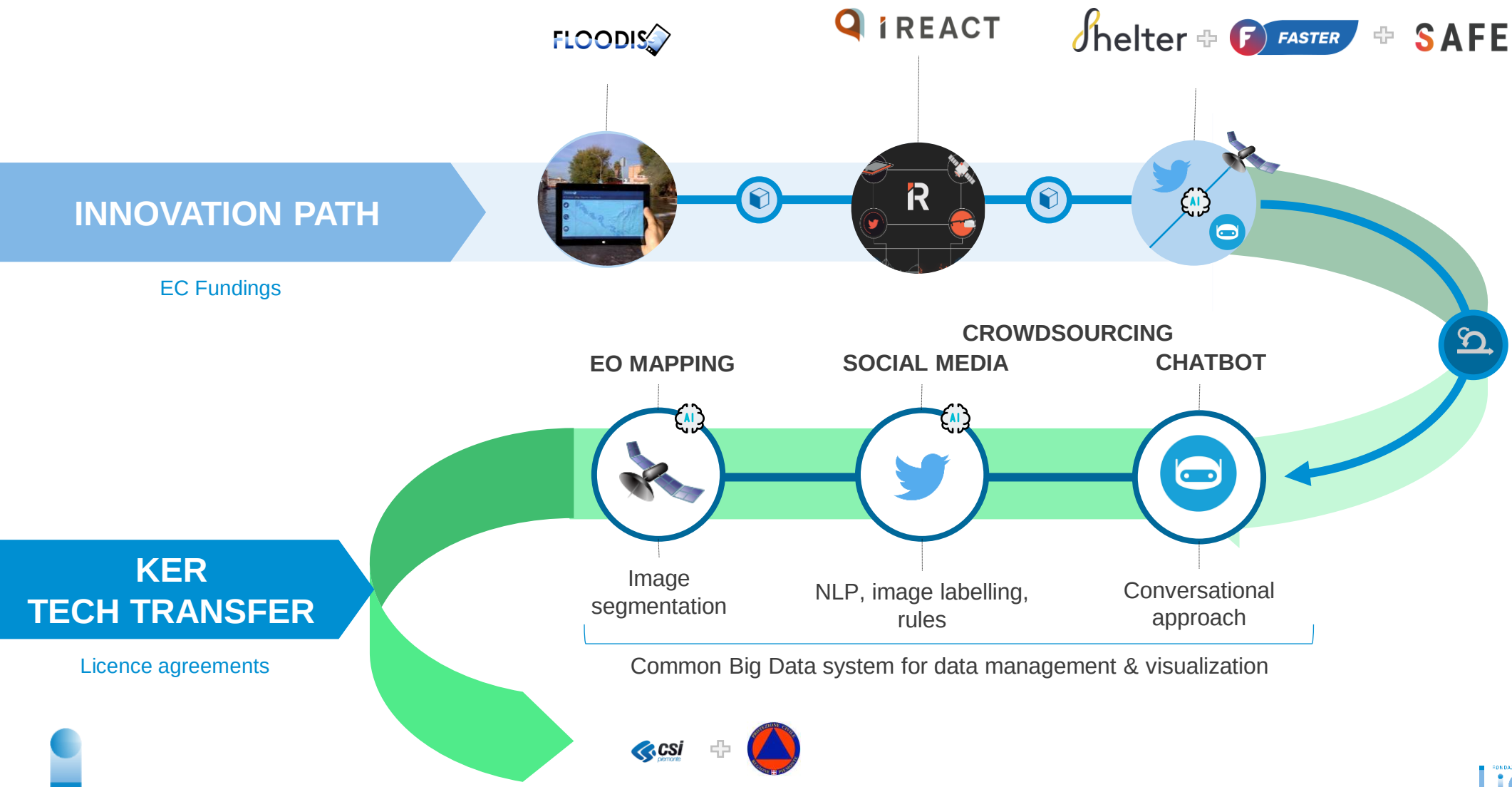
An experience to move from European projects to an impact on the society



# ERMES - Enhancing Resiliency to Manage Emergency Situations

#AI #Big Data #Cloud #Crowdsourcing #Chatbot #Azure #Marketing #Mobile #BigData

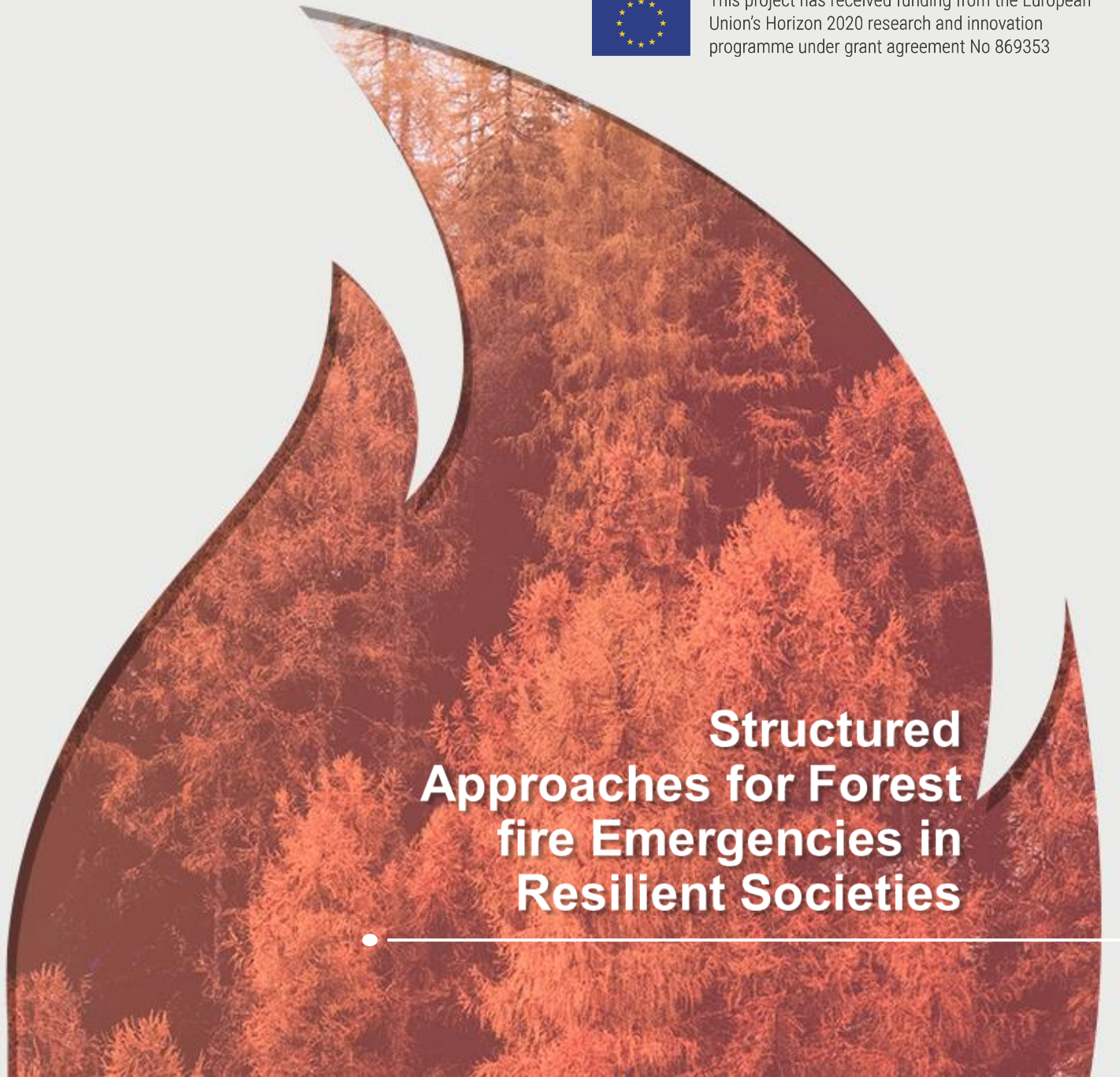
FLOODIS | iREACT | Shelter + FASTER + SAFERS



SAFERS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869353

# Project Overview & Selected Innovations



# Forest Fires: State-of-play

- Increasing susceptibility to fires are attributed to two main and interacting factors:
  - **climate change**-driven changes in weather extremes,
  - widespread **land use** change.

- Globally, massive fires have swept through forests and other landscapes in an alarming rate, resulting in the loss of human lives, destruction of homes and biodiversity, and emitting millions of tons of CO2 and other pollutants in addition to various destructive impacts.

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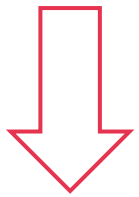
# Structured Approaches for Forest fire Emergencies in Resilient Societies

The need of **management of forest fires** has become **very crucial!**



**SAFERS**

An EU-funded project which will create an open and integrated platform for **effective management of forest fire emergencies**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869353

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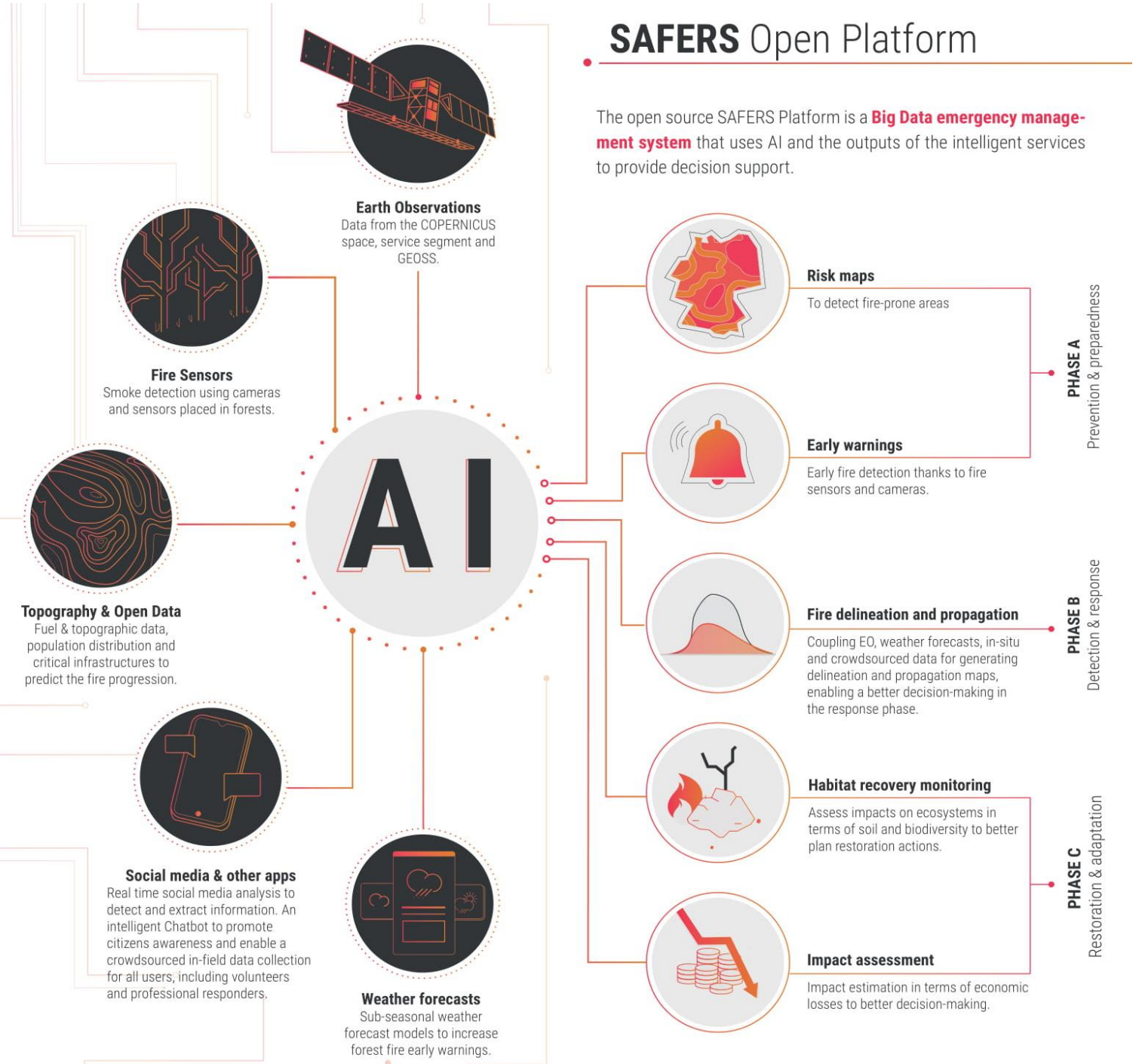


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The SAFERS project is going to develop an **open platform** which integrates several data sources and transform them into **actionable information** and **services**.

To test the system, there will be four demonstrations (in **Italy**, **Spain**, **Greece** and **France**)

# Selected Research Overview

1. Social Media Analysis (SMA)
2. Intelligent Chatbot
3. Burned Area Mapping (BAM) and impact assessment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869353

# 1. The pope election



**7 billions** of humans today are able to acquire, produce and share data.

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# 1. Social Media Analysis (SMA) - Objective

**Objective:** enhance the capability of EO mapping through a proper merge of textual and multimedia information about wildfire events from both the Chatbot and Social Media. This module will be based on state-of-the-art artificial intelligence algorithms to implement:

- **Real-time content classification:** to extract meaningful information about wildfires from social media and the Chatbot
- **Event Detection:** it will also trigger other intelligent services to enable the gathering and analysis of satellite images of the affected area.
- **Event Tracking:** track the temporal and spatial extent of the event
- **Periodic reporting:** to summarize the ongoing situation in terms of impacts

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# 1. SMA: Functionalities

## MAIN FEATURES:

a) Filter and classify tweets and content:
- Informativeness, information type, hazard type, Named entity extraction, Image content classification, **help request**

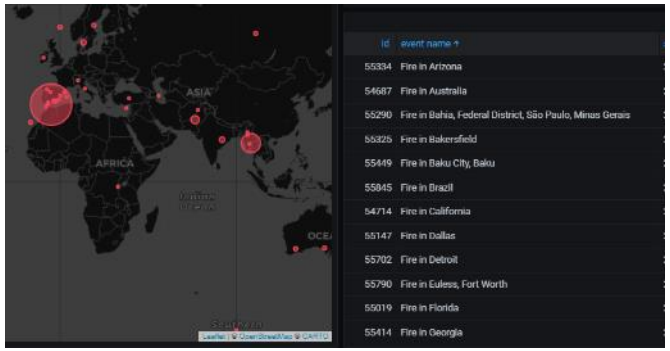
b) Detect Event
- Estimate location, start and end time

c) Impact extraction
- Affected people and infrastructures

d) Data validation

| Label | Description |
|---|---|
| People affected | Information about people affected, injured, found or missing |
| Infrastructures and utilities | Information about damaged buildings, roads, services |
| Caution and advice | Information about caution and advices from authorities |
| Donation and volunteering | Information about donations, rescue and volunteering efforts |
| Other information | Information that does not fit into other categories |

a

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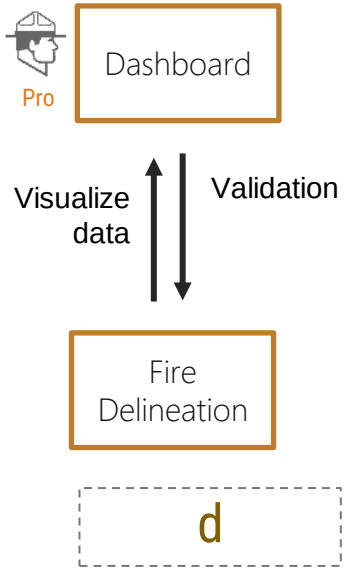


d

| Infrastructures | Population |
|---|---|
| Category | |
| Residential | Infected |
| Power Network | Dead |
| School | Evacuated |
| Water Network | Missing |
| Facility | Injured |
| Road | Recovered |
| Port | Rescued |
| Bridge | Hospitalized |
| Airport | |
| Hospital | |
| Cultural Heritage | |

c

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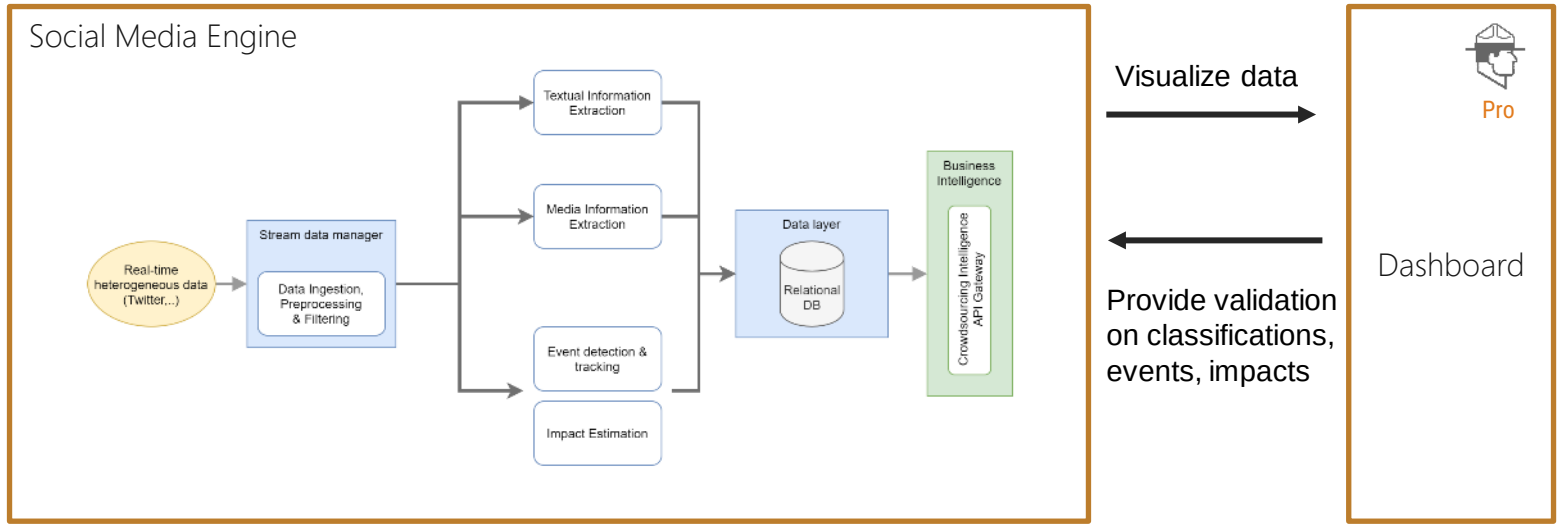
# 1. SMA: Service Oriented Architecture

- Filter and classify tweets and content:
  - Informativeness, hazard type, NER, images, help requests
- Detect events:
  - Estimate location, start and end time
- Extract impact estimates:
  - Info such as affected people and infrastructures
- Data validation

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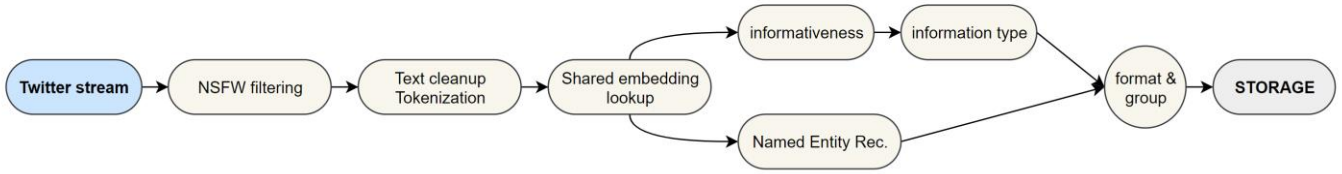
# 1- SMA: AI Models for textual classification

- **Data:**
  - Crisisilex, CrisisNLP, I-REACT labels
  - ~ 70 emergency events
  - ~ 113k Tweets
- **Models**
  - NSFW filtering: rule- and regex-based flow
  - Preprocessing: Multilanguage embeddings (FastText MUSE)
  - Classifications: CNN (informativeness, information type)
  - Named Entity Recognition: LSTM (Named Entity Recognition),
- **Focusing on:**
  - LOC – locations (e.g., Mount Fuji)
  - GPE – Geo-Political Entities (e.g., Japan)
  - TIME – time and dates (e.g., 13th march)




| | Precision | Recall | F1-score |
|---|---|---|---|
| Caution and advice | 0.61 | 0.83 | 0.70 |
| Donation and volunteering | 0.80 | 0.89 | 0.84 |
| Infrastructures and utilities | 0.60 | 0.83 | 0.70 |
| Other information | 0.87 | 0.65 | 0.74 |
| People affected | 0.77 | 0.78 | 0.78 |
| People injured or dead | 0.81 | 0.96 | 0.88 |
| People missing or found | 0.57 | 0.86 | 0.69 |
| F1 micro-averaged = 0.7677 | | | |
| Informative | 0.8697 | 0.8595 | 0.8802 |

S Piscitelli, E Arnaudo, C Rossi, "Multilingual Text Classification from Twitter during Emergencies" – IEEE International Conference on Consumer Electronics (ICCE)

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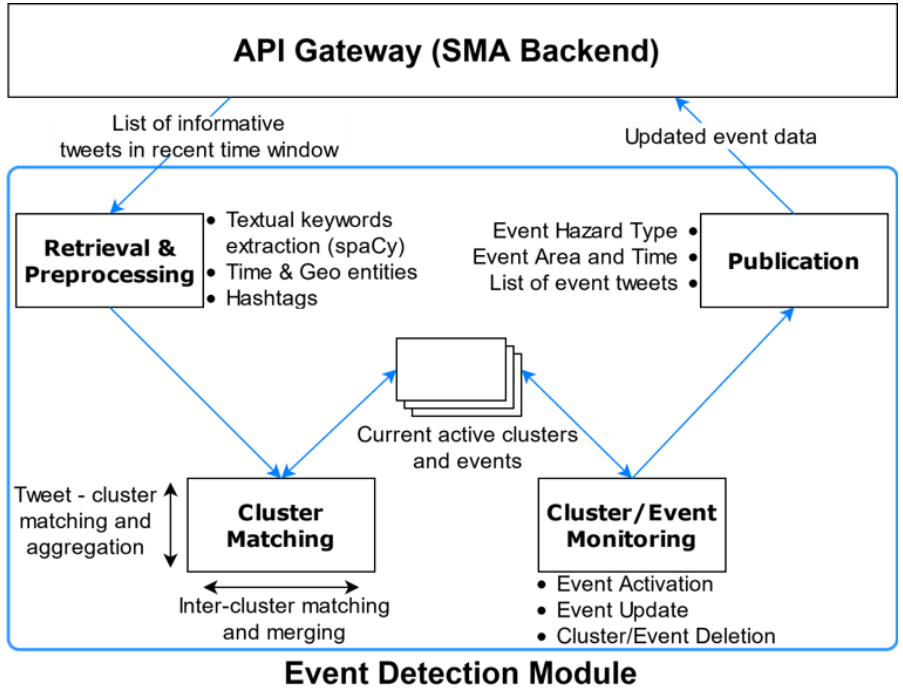
# 1. SMA: AI Models for Event Detection

- **Data intake**
  - Tweets classified as informative from the previous modules fetched every 5 minutes
  - Module currently active on English, Spanish, Italian, and Greek content
- **Real-time (online) clustering**
  - real-time clustering according to keywords and entities.
  - If no compatible cluster exists, a new one is created
  - Tweets for the same event may initially create new clusters
  - Clusters are compared and merged if grown similar
- **Activation**
  - A cluster is activated (i.e., becomes a detected event) if it contains enough tweets from unique authors (3-6) within a predefined time window.



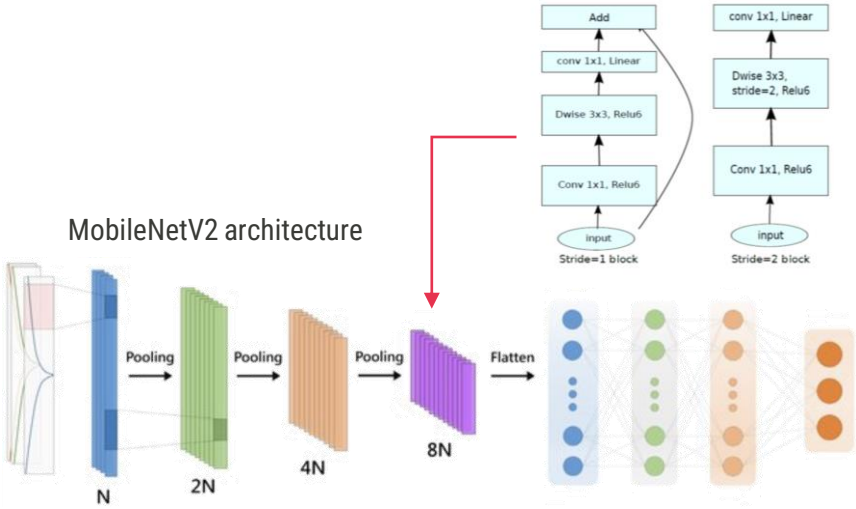
Event Detection Module

D. Salza, G. Blanco, E. Arnaudo, C. Rossi, “A global approach for real-time emergency event detection in Twitter”, ISCRAM 2022 Conference Proceedings – core paper

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 869353

# 1. SMA: AI Models for image classification

- Training Data:
  - Places365, Incidents datasets
  - ~ 100k+ images
- Flow:
  - NSFW filtering to exclude unwanted content
  - Multilabeling to classify images
- Models
  - NSFW filtering: MobileNet V2
  - Multilabeling: MobileNet V2




Ranked list of relevant images related to an emergency event

Inference and accuracy performances

| CNN Architecture | CPU Time (ms) | GPU Time (ms) | Incidents mAP | Places mAP |
|---|---|---|---|---|
| Resnet18 | 52.34 | 4 | 62.33 | 46.33 |
| Resnet50 | 544.12 | 18.03 | 68.22 | 46.21 |
| MobileNet V2 (Ours) | **11.62** | **0.19** | 68.00 | 45.95 |

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# 1. SMA: AI Models for Impact Estimation

- Rule-based approach:
  - Objective: detect and parse useful information to estimate a fixed list of impacted categories (see table).
  - Rules to match tweets containing specific words or patterns.
- Impact estimation steps:
  - Match tweets containing information
  - Detect and parse numerical data
  - When a category is matched, impacted is set to True
  - When to numerical info can be associated the count is not updated.
  - For each category the maximum value is calculated considering the 10 most recent tweets

- Military terrorists killed 91 innocent civilians today across # Myanmar . # WhatsHappeningInMyanmar...
- … 4 were injured and 3 were shot dead by military junta terrorists in Lashio . Video is of protestors trying to save a life , calling ambulance as the roads are blocked by terrorists ...
- Arson attack by terrorist military troops destroyed ard 70 houses in Mandalay . Locals said terrorists stopped them
- In Thaketa , a young man was shot and killed by the Terrorist Military Council . Two were injured # WhatsHappeningInMyanmar # Mar 29 Coup

| Infrastructures | | | Population | | |
|---|---|---|---|---|---|
| Category | Impact | # | | Impact | # |
| Residential | True | 70 | Infected | False | 0 |
| Power Network | False | 0 | Dead | True | 91 |
| School | False | 0 | Evacuated | False | 0 |
| Water Network | False | 0 | Missing | False | 0 |
| Facility | False | 0 | Injured | True | 4 |
| Road | False | 0 | Recovered | False | 0 |
| Port | False | 0 | Rescued | False | 0 |
| Bridge | False | 0 | Hospitalized | False | 0 |
| Airport | False | 0 | | | |
| Hospital | False | 0 | | | |
| Cultural Heritage | False | 0 | | | |

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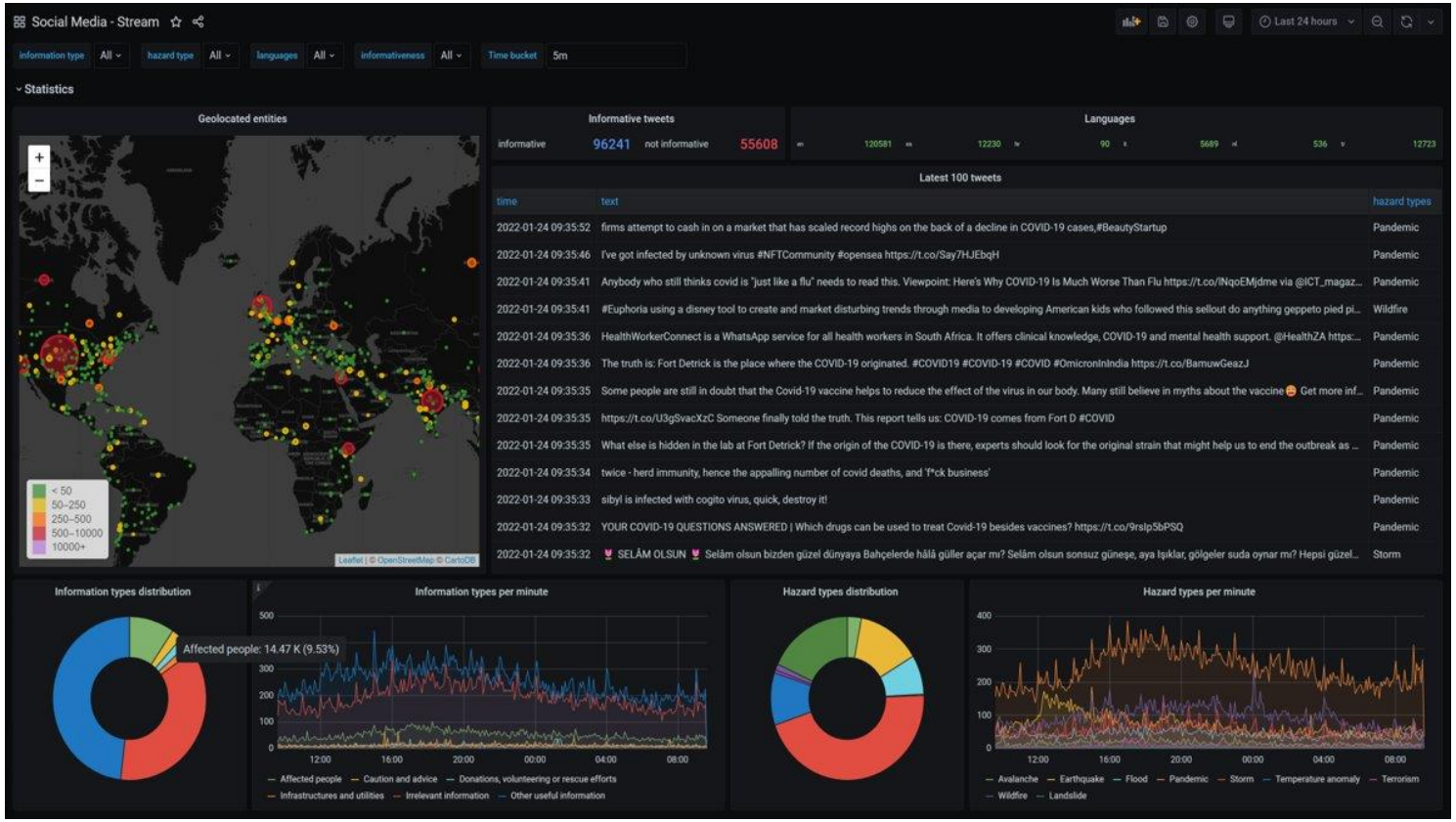
# 1. SMA: Grafana Dashboard – Tweet view

- **Worldwide geolocated entities**
- **Selection of tweets by:**
  - Language distribution
  - Informativeness and info. Type
  - Hazard type
- **Space and time filtering**
- **General statistics regarding:**
  - Info. Type counts
  - Hazard counts
  - Informativeness, languages
- **Hazard type graphs:**
  - left: distribution over the total
  - right: distribution over time

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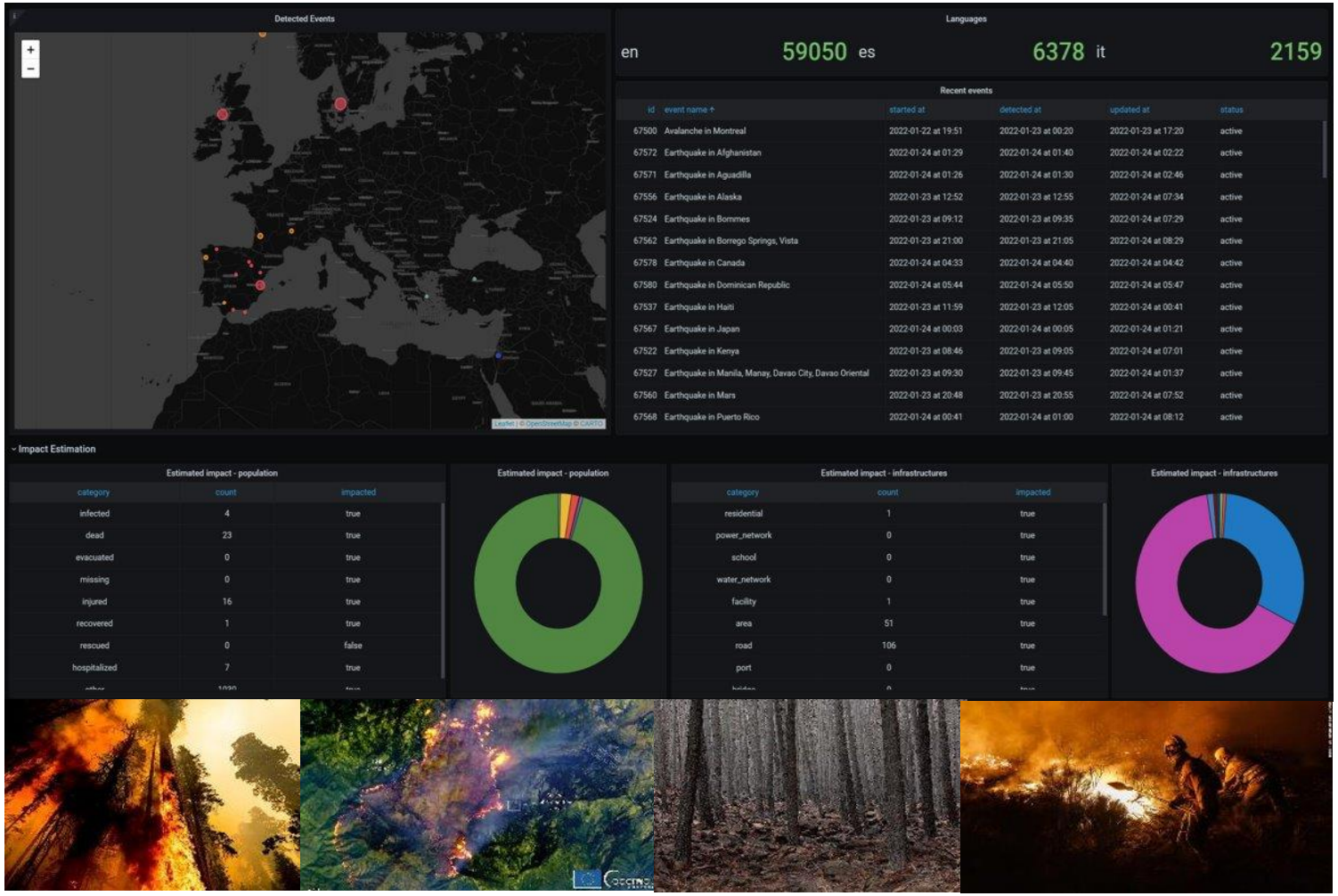
# 1. SMA: Grafana Dashboard – Event view

- **Worldwide geolocated events**
  - size: amount of tweets
  - color: hazard type
- **Selection customizable by:**
  - Language distribution
  - Hazard type
  - Geographical area
  - Time interval
- **Impact estimation with fixed taxonomy:**
  - affected population
  - affected infrastructures
- Events also provide **informative images,** if any.

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# 1. SMA: Live demo


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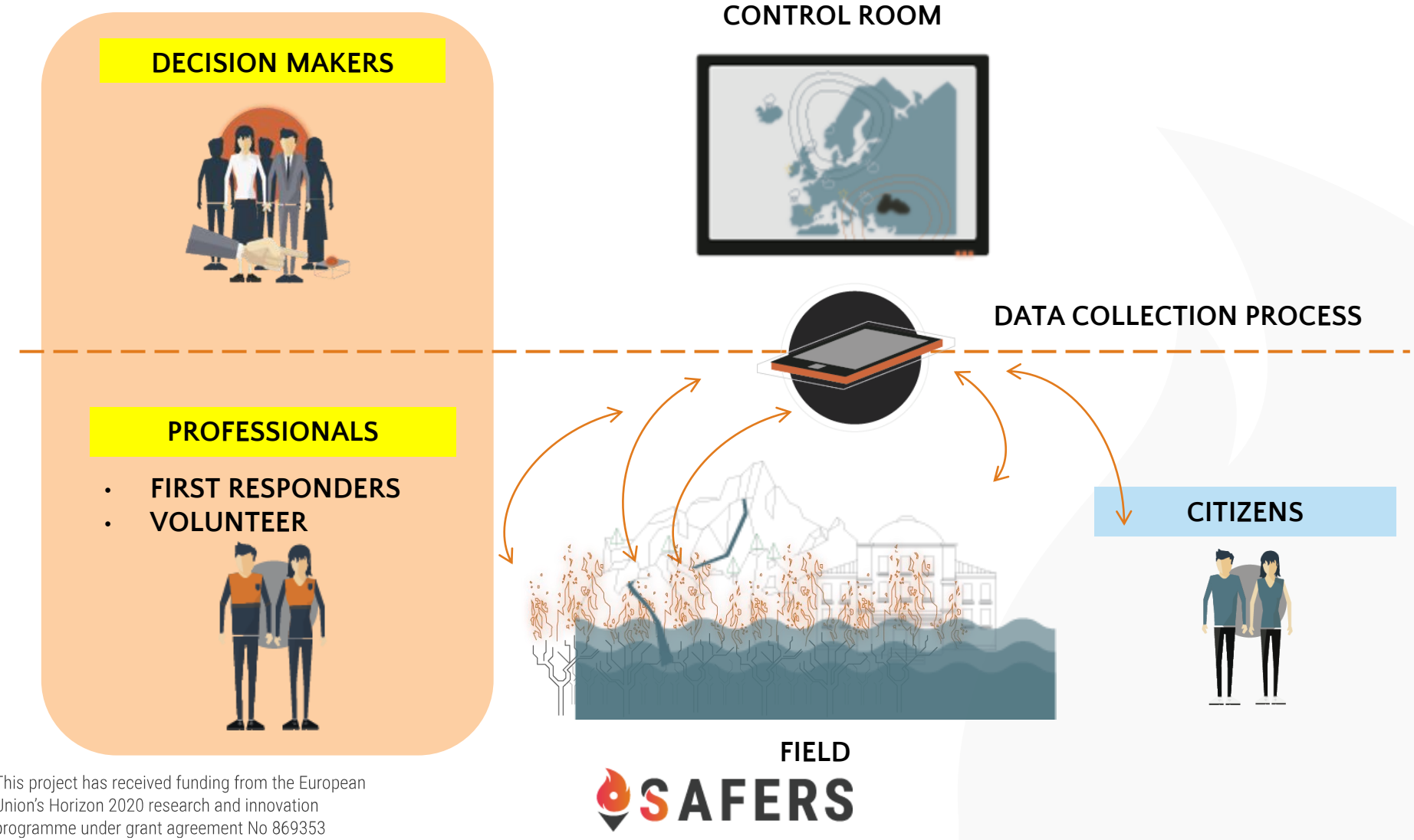
# 2. Chatbot: A structured data collection tool for Pro and citizens

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# 2. Chatbot: main features

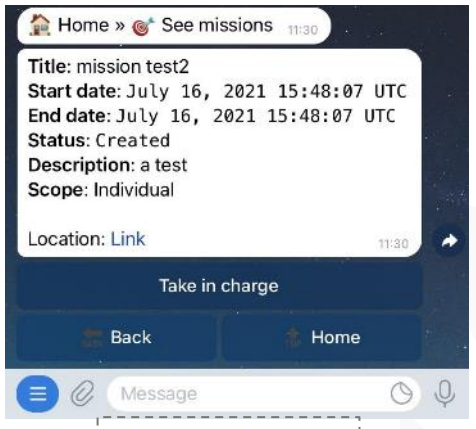
a) **People and resource management**
- Track deployed people, their status and activity. Get an overall view of deployed resources

b) **Mission management**
- Instruct and monitor the evolution of missions assigned to in-field forces

c) **Crowdsourced data collection (reports)**
- Instruct and monitor the evolution of missions assigned to in-field forces

d) **Communication with citizens**
- Communication on forest fire risks and self-protection behavior according to early warning information


a

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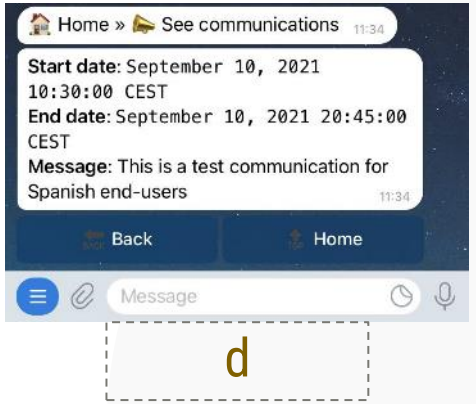


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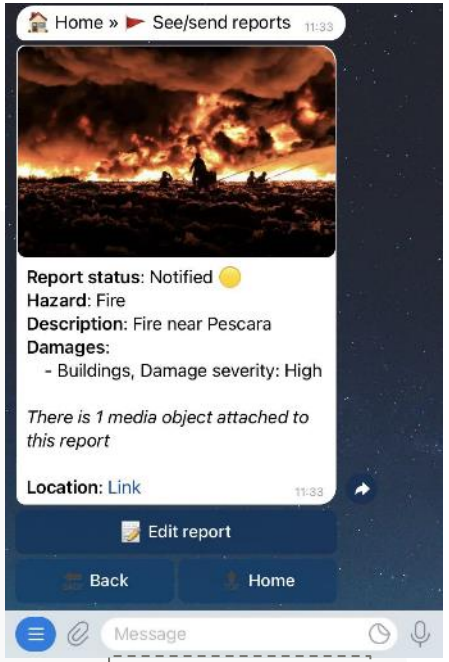


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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869353

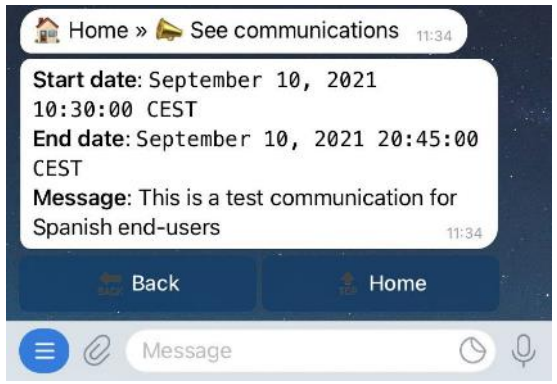
# 2. Chatbot: Main Interactions

**TRIGGER**: Early warning, Event detected, Situational update, Post-event activities
**ACTIONS**:

TOUCHPOINT

Bot

Receive and read communication updates on the current of forecasted situation

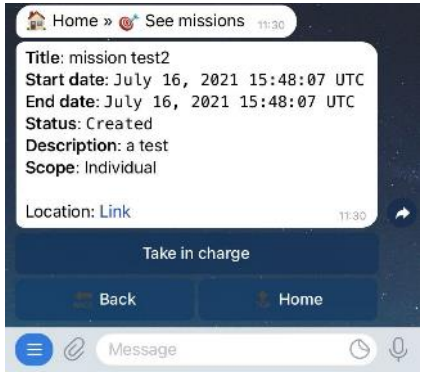



Citizen Pro

Share the location, set the operational status and activity

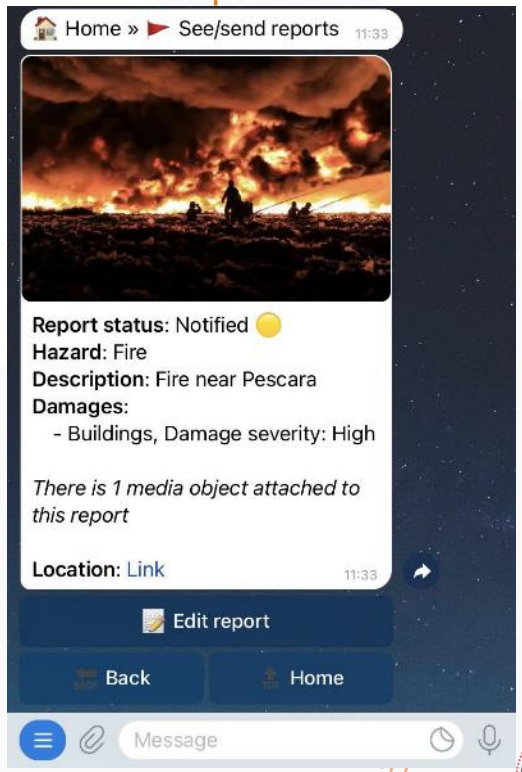

Pro

Receive and execute mission (e.g. surveillance)




Pro

Create geolocated multimedia reports




Citizen Pro

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SAFERS

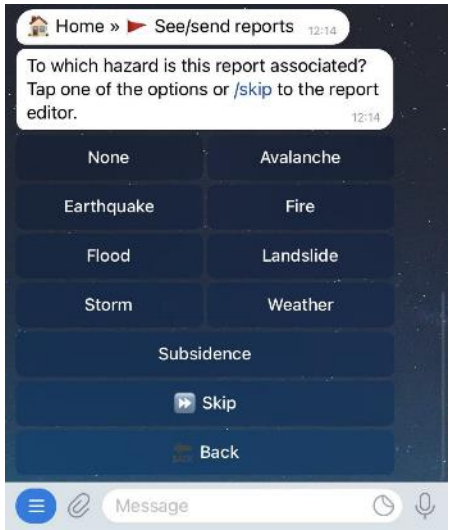
# 2. Chatbot: report creation

**TRIGGER**: Early warning, Event detected, Situational update, Post-event activities
**ACTIONS**:

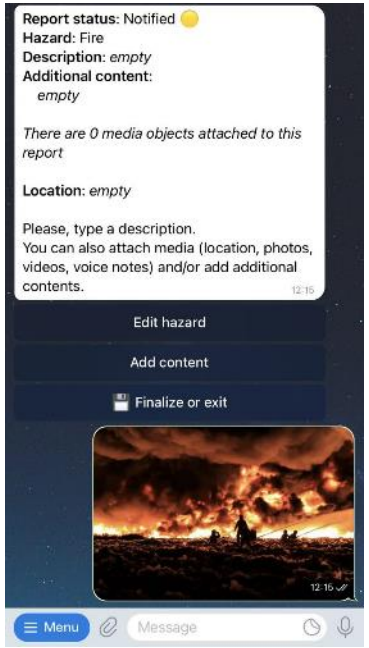
**USERS** Citizen Pro

**TOUCHPOINT** Bot

## Hazard selection

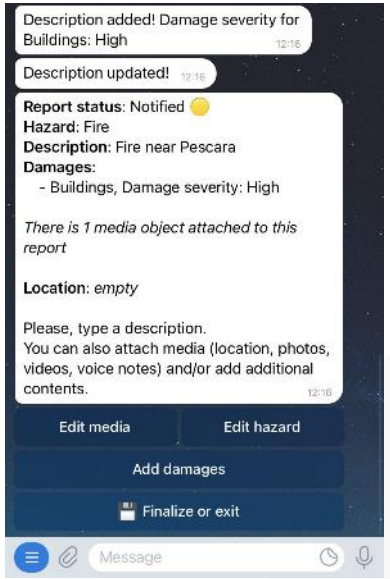



## Multimedia attach

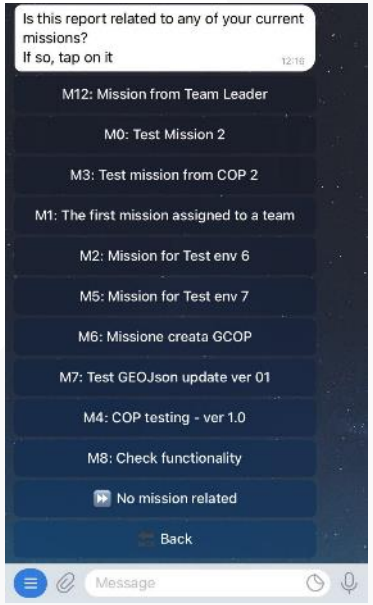



## Additional content

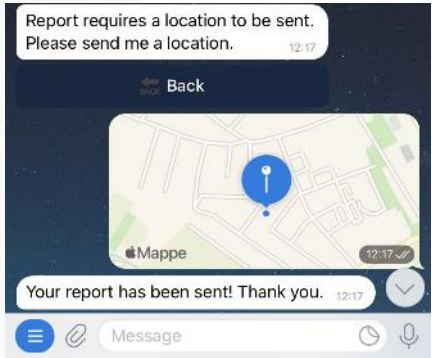

## Content specification




## Link with ongoing mission




## Send!

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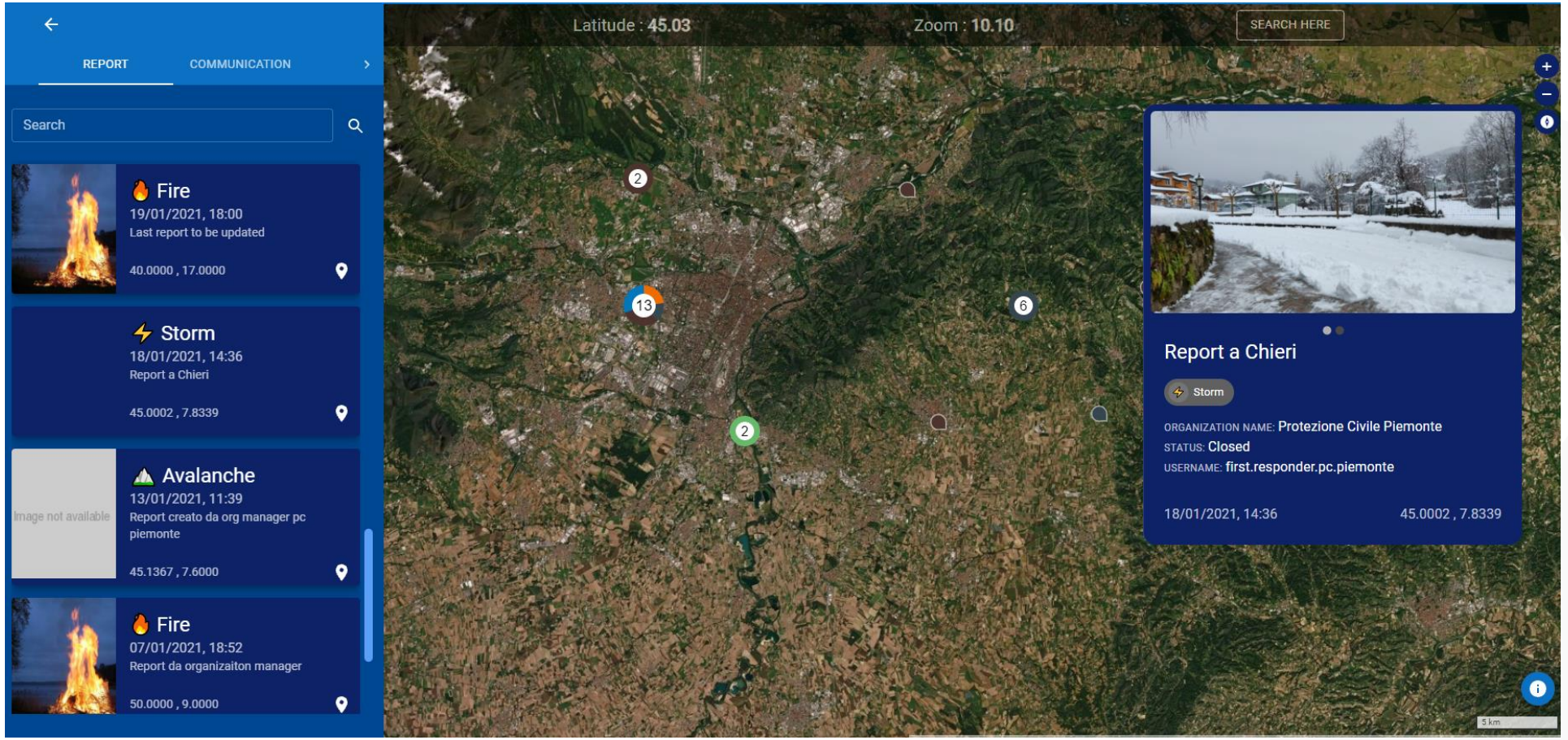
# 2. Chatbot: data visualization at the control center

## EXPECTED OUTCOME




**USERS**

Citizen

Pro

**TOUCHPOINT**

Dashboard

Real-time overview of in-field agents, list of executed missions with geolocated multimedia reports (people, damages, measures)

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# 2. Chatbot: Live demo


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# 3. EO-based fire and Burned Area Mapping (BAM)

**Objective:** deliver ML-based module capable of delineating burned areas and on-going fires from Sentinel data.

**Service Flow:**

- Retrieve remote **sensing images** (DIAS or other EO services) and **burned area maps** (e.g. Copernicus EMS) to create an initial training dataset, to obtain **supervised deep learning models**.
- Deploy the most performant models for **on-demand rapid mapping** of a given Area of Interest (AoI), in a specific period, optionally over time.
- Deliver inputs and outputs to the **web application platform**, storing outputs into a **GeoData Repository**.

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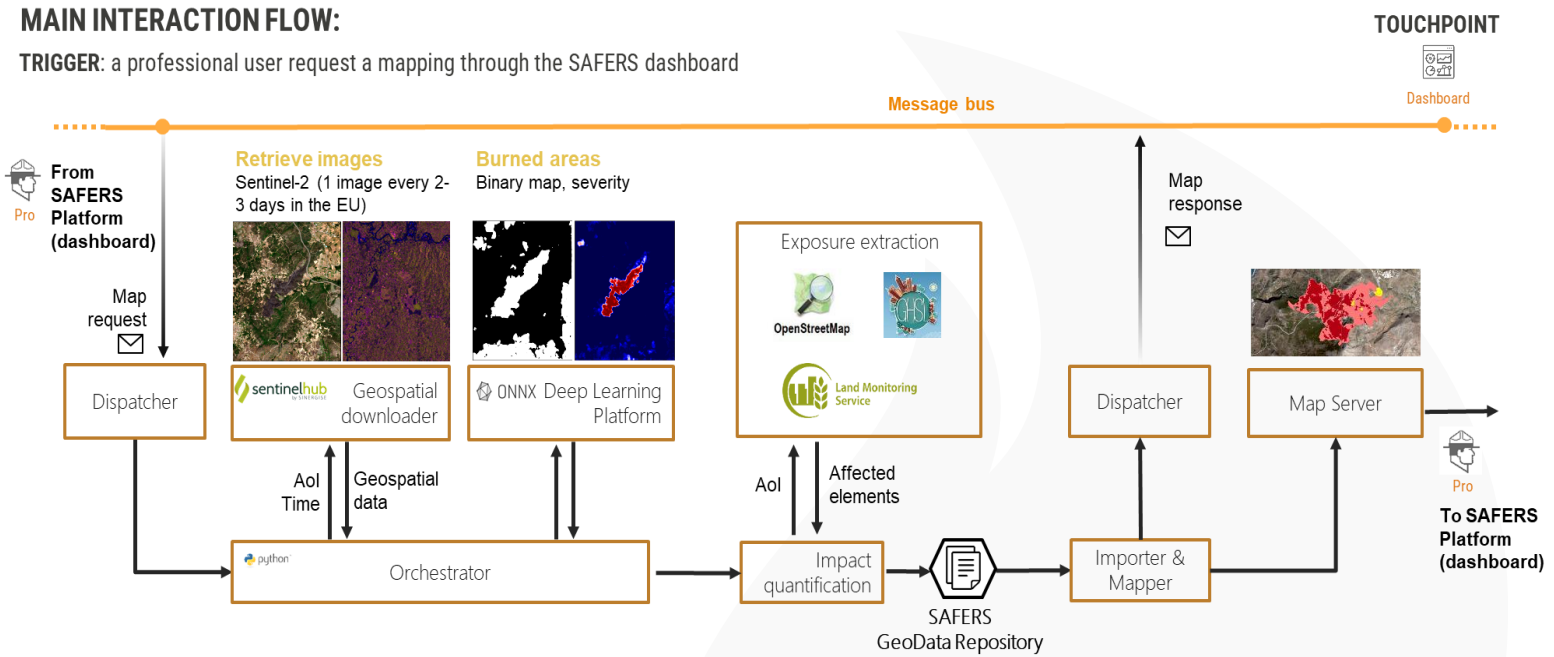
# 3. BAM: Service Data Flow

## Requirements:

1. **On demand:** End-user can request a mapping by specifying the area of interest and a temporal range of reference
2. **AI models:** delineation of burned area, fire front, smoke from Sentinel-2 imagery
3. **Impact assessment:** metadata on impacts if terms of affected land (by vegetation type) and infrastructures. Severity indexes (dNBR, novel deep learning model) and quantification of affected targets
4. **Format:** communication on forest fire risks and self-protection behavior according to early warning information



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SAFERS

# 3. BAM: Service Outputs (i)

## A. Sentinel-2 image of the wildfire

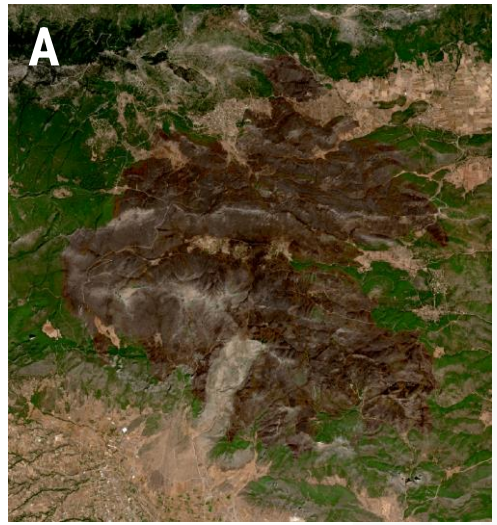
Raw Sentinel-2 image, used as input for the ML models.

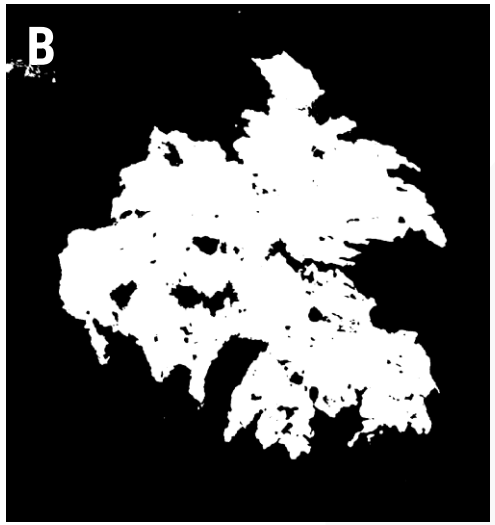
## B. Burned area delineation

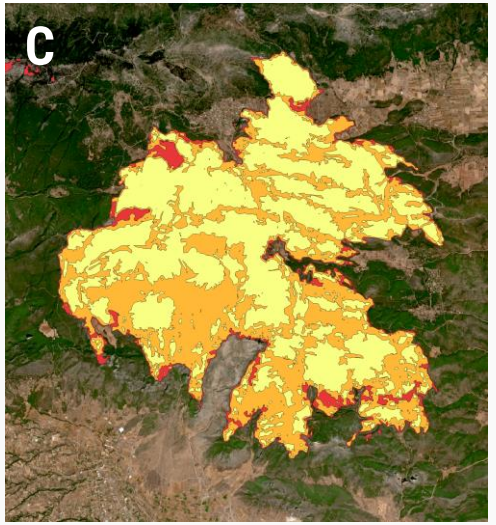
Binary georeferenced image delineating pixels of burned areas.

## C. Burn severity estimation

Georeferenced image indicating the burn severity for each pixel.

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# 3. BAM– Service Outputs (ii)

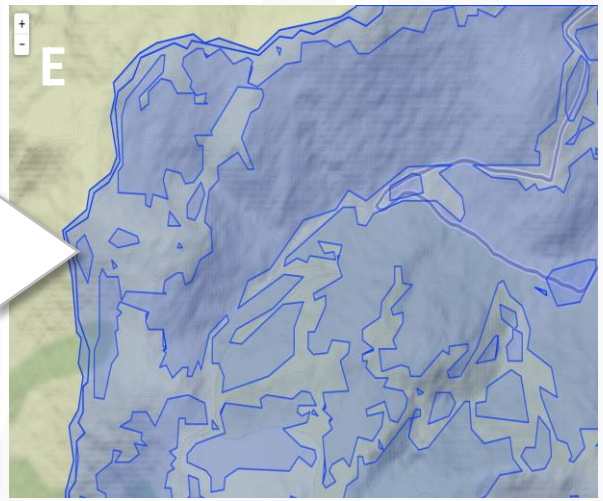
- **D. Fire front and smoke detection**

GeoTIFF indicating fire front and smoke

- **E. Impact assessment**

GeoJSON FeatureCollection of areas and relative impacts

| | |
|---|---|
| landcover | {<br>id:211,<br>description: "Non-irrigated arable land",<br>area:49.9838,<br>unit: 'ha'<br>} |
| population | 21 |
| severity | 2 |
| Affected inftrastructures | … |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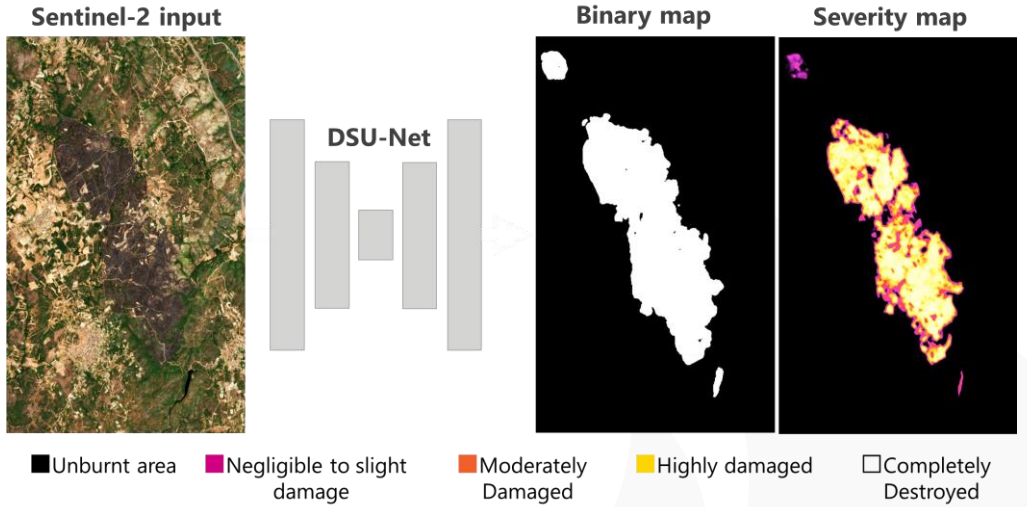
# 3. BAM: Model & Performances

- Given a delimited area, obtain its Sentinel-2 feed, and estimate burned areas using deep learning techniques.
- Produce:
  - a binary mask estimating the extents of the burned area.
  - a severity map for damage assessment.
- Workflow:
  - Wildfire events drawn from Copernicus EMS to construct a training set.
  - Train and benchmark a segmentation and regression model (DSU-Net) [1].




| Task | Method | Metric | Score |
|---|---|---|---|
| Flood delineation | Thresholding | F1 | 0.7515 |
| Flood delineation | U-Net (Ours) | F1 | **0.8601** |
| Burned area del. | Single U-Net | F1 | 0.8231 |
| Burned area del. | Double-step U-Net (Ours) | F1 | **0.8812** |
| Severity estimation | dNBR | RMSE | 0.9180 |
| Severity estimation | Double-step U-Net (Ours) | RMSE | **0.8760** |

We test our models against manually validated **Copernicus EMS activations**.

[1] Farasin et al., *Double-Step U-Net*, MDPI Appl.Sci., 2020, 10(12)

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# 3. BAM: Live demo


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# Q&A

Thank You!

FONDAZIONE links

PASSION FOR INNOVATION