Project Number 700099
Call: H2020-DRS-01-2015

Project Title:

ANYWHERE

EnhANcing emergencY management and response to extreme WeatHER and climate Events

Subject:

Deliverable 5.2:
Report describing the products, services and results of the 4 case studies in Tasks 5.3-5.6

Dissemination Level: PU

Delivery date: **31st July 2019**
Month: **Month 38**
Organisation name of lead contractor for this deliverable: **RINA Consulting S.p.A.**

European Commission

This project has received funding from the European Union's H2020 Programme under the topic of potential of current and new measures and technologies to respond to extreme weather and climate events under grant agreement no. 700099.

Document Information

Title	**Report describing the products, services and results of the 4 case studies in Tasks 5.3-5.6**
Lead Author	Vincenzo Cerreta (RINA-C), Ivan Tesfai (RINA-C)
Contributors	Andrea Poggioli (RINA-C) Marta Speranza (RINA-C) Jens Pottebaum (UPB) Jordi Roca (HYDS) Marc Berenguer (UPC-CRAHI) Carlos Carmona (UPC-CRAHI) Ilona Lang (FMI) Nicola Rebora (CIMA)
Distribution	PUBLIC
Document Reference	ANYWHERE Deliverable D5.2

Document History

Date	Revision	Prepared by	Organisation	Approved by
16.02.2018	Rev_0_1	Ivan Tesfai	RINA-C	Jens Pottebaum
13.05.2019	Rev_0_2	Vincenzo Cerreta, Andrea Poggioli, Marta Speranza	RINA-C	Ivan Tesfai
21.06.2019	Rev_0_3	Jordi Roca	HYDS	Vincenzo Cerreta
21.06.2019	Rev_0_4	Marc Berenguer	UPC-CRAHI	Vincenzo Cerreta
26.06.2019	Rev_0_5	Ilona Lang	FMI	Vincenzo Cerreta
01.07.2019	Rev_0_6	Nicola Rebora	CIMA	Vincenzo Cerreta
10.07.2019	Rev_0_7	Vincenzo Cerreta	RINA-C	Ivan Tesfai
30.07.2019	Rev_0_8	Jens Pottebaum	UPB	ANYWHERE Coordination
31.07.2019	Rev_0_9	Marc Berenguer, Carlos Carmona	UPC-CRAHI	ANYWHERE Coordination
06.08.2019	Rev_0_10	Vincenzo Cerreta	RINA-C	Ivan Tesfai
24.08.2019	Rev_0_11	Ilona Lang	FMI	Ivan Tesfai
08.10.2019	Rev_0_12	Ivan Tesfai	RINA-C	ANYWHERE Coordination
07.11.2019	Rev_0_13	Alexandre Sanchez	UPC-CRAHI	ANYWHERE Coordination
26.11.2019	Rev_0_14	Ivan Tesfai	RINA-C	ANYWHERE Coordination

Related Documents

This report and others are available from the **ANYWHERE** Project Website at: http://www.anywhere-h2020.eu/

Summary

This document describes the products, services and results of four case studies carried out in the Tasks 5.3-5.6. As well, it includes the feedback of end-users during the development and implementation of the products and services presented.

The work foreseen in WP5 is based on two major assumptions:

1. Enterprises invest into business continuity and intend to adapt their existing tools and communication channels also for that purpose;
2. Citizen are intrinsically motivated for self-preparedness and self-protection (self-p*) representing a relevant value for money for self-p* enabling solutions as long as they are intuitive and user-friendly.

Both assumptions imply that there is a significant potential and innovation for the use of the ANYWHERE concept to enhance the self-p* of the citizens. ANYWHERE provides added value through information in terms of hazard indication (WP3) and decision support solutions (WP4), effectively integrating them to provide relevant information regarding impact on infrastructures and communities. WP5 provides concrete examples to increase the sustainability of this concept with the development of these self-p* applications.

Therefore, WP5 is designed based on representative case studies which are consistent, relevant as individual cases and modular to allow transfer of results to enhance the self-p* of the citizens in general.

Four case studies are defined:

- Reducing storm-driven impacts on electricity transmission grids (Task 5.3);
- Enabling self-response of the logistic platforms of the food distribution companies during severe weather events (Task 5.4)
- Increasing self-protection in camping located in flood prone areas (Task 5.5)
- Increasing self-awareness and self-protection in front of flooding risk in schools (Task 5.6)

For each case study, the products and services are enabled through the services and interfaces of the MH-EWS (WP3) demonstrating the commercial capability of ANYWHERE to consider the perspective of different target users, in compliance to the assumptions made. Specifically, the products and services considered are:

- Predictive tools for power outages in an electrical power grid due to hazards produced by convective storms (FMI);
- A service to support decision-making in the management of truck fleets of food distribution companies by forecasting the impacts of heavy rain and snow on the conditions of the road network and their performance (in terms of road capacity, travel time, speed, queues and routes) (RINA-C, UPC-CRAHI);
- A service for issuing warnings in camping areas in flooding areas connected with their self-protection plans (HYDS);

- A service to improve and speed-up the communications between schools, emergency managers and parents able to suggest in case of an emergency related to flood the safer behavior to protect their children and themselves, in order to better react during this kind of events (CIMA).

Table of Contents

1 Introduction

This deliverable presents a range of products and services as results of four case studies in Tasks 5.3-5.6:

- Task 5.3: Reducing storm-driven impacts on electricity transmission grids;
- Task 5.4: Enabling self-response of the logistic platforms of the food distribution companies during severe weather events
- Task 5.5: Increasing self-protection in camping located in flood prone areas
- Task 5.6: Increasing self-awareness and self-protection in front of flooding risk in schools

WP5 envisages raising self-preparedness and self-protection of citizens, enterprises, and other organisations to reduce population vulnerability to extreme weather events. Therefore, four new self-p* tools have been developed based on the products provided by the ANYWHERE Multi Hazard Early Warning System (MH-EWS), and therefore demonstrating the commercial capability of ANYWHERE to consider the perspective of different target users.

Specifically, the products and services considered are:

- Predictive tools for power outages in an electrical power grid due to hazards produced by convective storms (FMI);
- A service to support decision-making in the management of truck fleets of food distribution companies by forecasting the impacts of heavy rain and snow on the conditions of the road network and their performance (in terms of road capacity, travel time, speed, queues and routes) (RINA-C, UPC-CRAHI);
- A service for issuing warnings in camping areas in flooding areas connected with their self-protection plans (HYDS);
- A service to improve and speed-up the communications between schools, emergency managers and parents able to suggest in case of an emergency related to flood the safer behavior to protect their children and themselves, in order to better react during this kind of events (CIMA).

The implementation of the products and services designed in Task 5.3 – Task 5.6 in the pilot sites has been achieved with the milestone MS11 (M29), demonstrating the ANYWHERE capabilities to provide added value through information in terms of hazard indications and decision support, sustain the uptake of outcomes by using the hazard and impact forecasting products generated by the MH-EWS and therefore to enable innovation for self-p* applications for a diversified range of users and stakeholders.

1.1 Scope

This deliverable presents the products, services and results within relevant use cases in terms of problem stated, description of the solutions, their development and implementation on the pilot sites and relevant users and stakeholders, simulation and results obtained according to the experience and feedback and of end user.

D5.2 represents the basis for a follow-up deliverable which reports on findings from different perspectives on impact of self-preparedness and self-protection tools and services (D5.3).

1.2 Document Organization

This document is arranged by focusing on the products and services of the four specific case studies.

The overall document structure is hereby presented:

- Section 1 contains the introduction to the document;
- Section 2 presents the products and services implemented and tested in the different case studies. For each case study, a specific sub-section is presented with the following structure:
    - Problem definition: description of the case study, scope, assumptions, and expected user benefit;
    - Development and implementation: description of the methodology and service (including integration aspects), models, calibration (potential), training;
    - Simulations and results: test plan and outcomes (verification)
    - User feedback: collection of the findings of case study to be used for the analysis of lessons learnt and best practices in Task 5.7
    - Identification of business case: consideration of potential business models and key value proposition
- Section 3 contains the conclusions and considerations for commercial capabilities of ANYWHERE solutions.

2 Case studies

To support the development of meaningful, innovative and successful self-p* tools, representative case studies have been built as foundations of WP5, specifically focused on:

- Reducing storm-driven impacts on electricity transmission grids (Task 5.3);
- Enabling self-response of the logistic platforms of the food distribution companies during severe weather events (Task 5.4)
- Increasing self-protection in camping located in flood prone areas (Task 5.5)
- Increasing self-awareness and self-protection in front of flooding risk in schools (Task 5.6)

The case studies are conceived to be:

- consistent and relevant as individual cases, answering to identified needs and stated problems;
- modular to allow transfer of results on different stakeholders minimizing customisation efforts and therefore demonstrating the replicability of the solutions.

2.1 Reducing storm-driven impacts on electricity transmission grids

This section describes tools for improving self-response of electricity companies during severe weather events like convective storms and low-pressure induced wind storms. The ANYWHERE project's electricity case study demonstrates the tools that provide better preparedness for electricity grid operators while facing severe wind or convective storm events.

The secured transmission of energy is one of the most important elements in the modern society. All over Europe the electricity demand has been and will be increasing. Therefore, it is important to discover reliable systems that are stable also when facing extreme weather events. In Finland, the energy transmission reliability is generally on a high level. Still despite the existing good level of preparedness, annually from 50 to 350 MWh of energy is not delivered through the main grid valuating to 1.5 to 6.0 M€ (Fingrid, 2018). In Europe, hazards associated with convective weather (e.g., lightning, downbursts, and heavy precipitation) cause several billions of euros worth of damage in Europe on a yearly basis (Ukkonen & Mäkelä, 2019). In this context, the secure operation of the electricity transmission network is also a significant interest in the field of research.

The main causes for the outages in Finland are meteorological hazards: strong winds of convective and wind storms may disrupt and even destroy the grid or cut down trees that fall over the air transmission lines. The latter is often the eventual impact that causes an outage, and is usually the most important in densely forested countries such as in Finland.

In the beginning of the project, the goal was to introduce in a case study an impact tool for the convective thunderstorms that dominate the weather-related issues in the electricity transmission during the summer. However, as a further development step, we also introduce a preliminary concept for a winter tool as well (Láng, 2017). The winter tool is for forecasting the impacts of extratropical induced wind storms that rule the weather in the winter season. Strong winds cause damages for electricity transmission grids also during winter. During the cold Finnish winter, electricity distribution disruptions can be even more dangerous for the public. The rural areas are especially sensitive for these disruptions if the heating of the houses depends on electricity. The development of the tool was initiated in a late phase as an outcome of this project and it is currently under development at FMI. The following sections mainly focus on describing the development, validation and user experiences of the convective storm forecasting tool, i.e. the summer tool.

The ANYWHERE tools for storm events are provided through a web-based service for the stakeholder. The piloting and development of the tools were done in close co-operation with Järvi-Suomen Energia, member of the Stakeholders' Board of the project. The official testing period for the convective storms tool took place during the summer 2018, however preliminary testing was done already in 2017 and continued also during summer 2019.

This service supports the decision making and improves the planning of placing the resources of the electricity companies over severe weather events that can have a negative impact on operational performance. The tool can be utilized on different levels and employees of the company. The route and the recourse forecast are the most essential for the operational center, while the information about the economic loss plays bigger role for the management and communication of the company. In fact, indirectly also the citizens profit from the impact tools provided, since the electricity company utilizes the impact tools' information while informing to the customers e.g. on the duration of power outages.

The convective storm forecasting product provides the user several outputs that benefit the preparedness of the electricity company in different ways. The impact estimation appears for the end-user by clicking on an interactive the map.

The outputs of the method are:

1. The forecasted route of the convective cells
2. Severity of the convective cell based on the transformers affected (colors)
3. An impact estimation of the storm in:
    a. Euros
    b. kWh
    c. households without electricity
    d. Amount of the teams needed on the field to repair the faults
    e. The estimate of the power outage's duration
4. Archive of the past cases

The tools were developed by the Finnish Meteorological Institute, with close cooperation with the stakeholder, Järvi-Suomen Energia. The tools are based on the methods developed in the work of Rossi (2015), Láng (2017) and Tervo (2018).

2.1.1 Problem definition

Electricity transmission grids are in Finland as well as in many countries in Europe among the critical infrastructures that are often damaged due to weather related hazards. Significant weather events cause annually more than 50% of the electricity grid faults and electricity distribution disruptions in Finland (Figure 1).

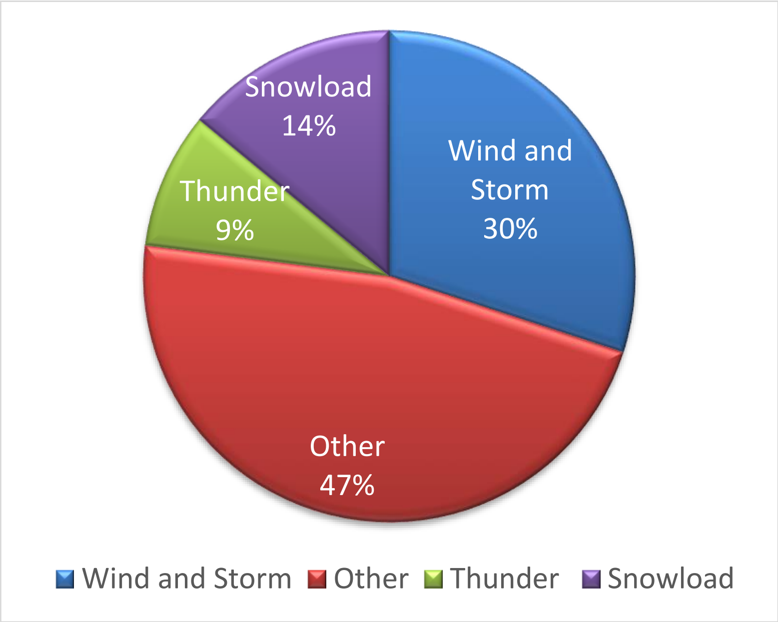


Figure 1: Causes of the electricity distribution interruptions in Finland 2005-2015 (Láng, 2017)

Severe weather cause yearly significant harm for electricity supply. Hazards produced by intense winds, lightning and tornadoes have considerable societal impacts and cause remarkable liability for damages for distribution companies (Figure 2). Thunderstorms and strong winds are among the most significant weather phenomena that cause disruptions – and because of convective storms' rapid development, the preparation time for the event can be counted in hours or even in minutes. In addition, the forecasting of the thunderstorms is often challenging and prone to significant uncertainty. (Rossi, 2015) The damaged area in thunderstorm cases is often small and local, however, the damages can be extremely severe and cause significant monetary loss for the society. For example, during the Asta thunderstorm (2010) forest damages, electric power networks, and particularly distributing networks, were destroyed in the storm impact areas, particularly in Eastern and Central Finland. The estimated financial losses of Asta storm were over 20 million euros. In contrast the damages of extratropical cyclone-induced wind events show a much wider distribution as seen in the Figure 3.

Figure 2: Examples of thunder and windstorm damages

a) b)

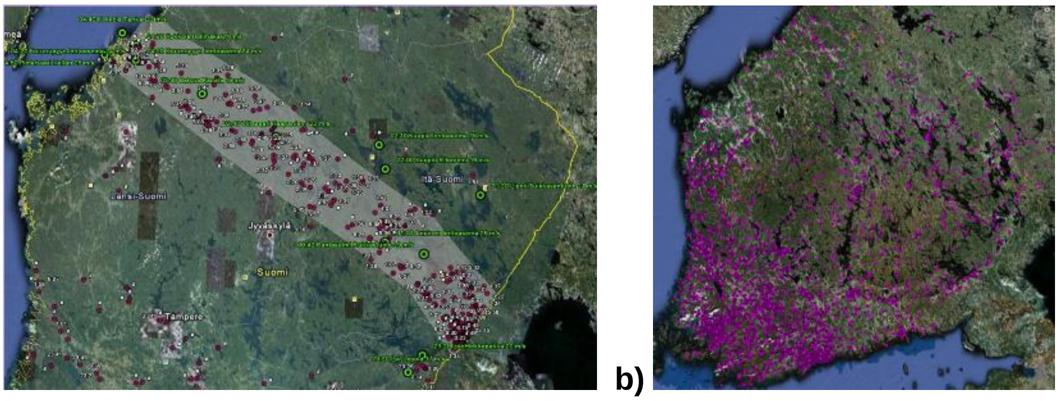


Figure 3: Electricity fault map during a) Asta thunderstorm 29-30/07/2010 b) Tapani low-pressure storm 24-27/12/2011

There are two main seasons for power distribution companies' weather-related challenges that are presented in Figure 4. The figure represents the monthly average of weather-related emergency calls. There is a correlation between the emergency tasks and the amount of the power cuts. Therefore, the seasons that can be identified from the emergency statistics reproduce the seasonality of the power cut damages as well. During July and August, the convective storms dominate the weather and its impacts on the society whereas November and December is the season for damages caused by low-pressure wind storms.

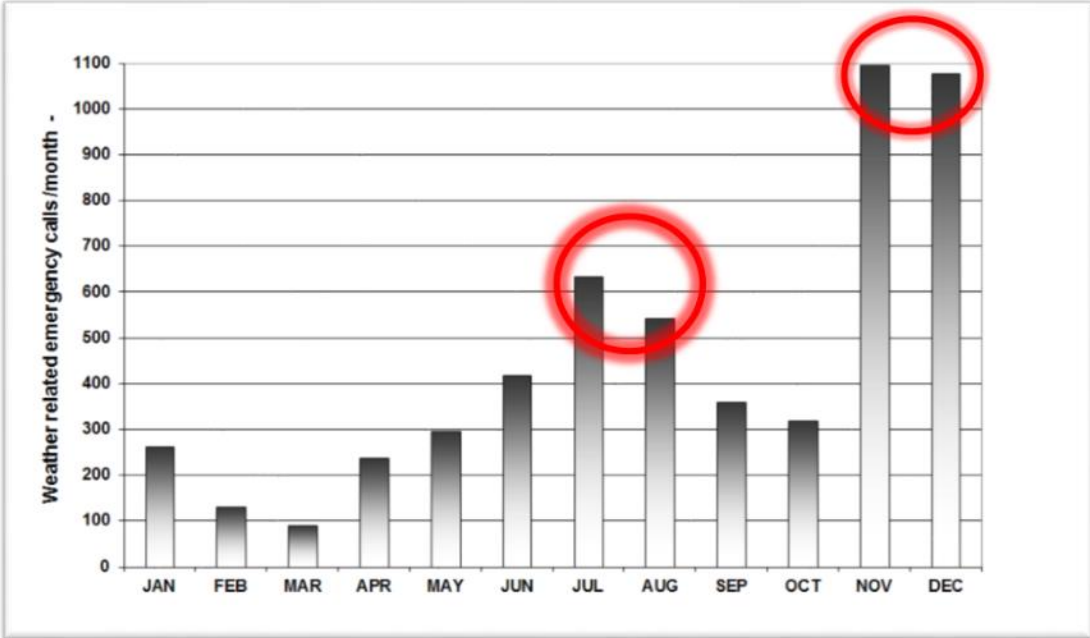


Figure 4: Weather related emergency calls per month in Finland (2001-2013). The occurrence of the emergency calls represents the seasonal variation in weather related emergencies. The weather induced emergencies correlate often with electricity disruptions.

In Finland, electricity distribution companies are responsible by law for paying compensation to their clients for power outages. If there has been a defect in the supply of electricity, the consumer is entitled to a reduction in the price of electricity corresponding to at least two weeks' payments of the annual network service fee. If the service interruption lasts at least 12 hours, the customer is automatically entitled to standard compensation. Longer the interruption, higher the standard compensation. The amount of compensation also depends on the consumer´s annual network service fee.

- 12–24 hours: 10% of the annual network service fee
- 24–72 hours: 25 % of the annual network service fee
- 72–120 hours: 50% of the annual network service fee
- 120–192 hours: 100 %
- 192–288 hours: 150 %
- More than 288 (12 days) hours: 200 % of the annual network service fee
- Maximum compensation is EUR 1500. (Valid until January 2018)

If there are several interruptions to the supply of electricity during one calendar year, the amount of compensation shall not exceed 200 percent of the annual network service fee or EUR 2000 (KKV, 2014). The interruption time is calculated from the moment the network operator becomes aware or can be considered to have become aware of the interruption. The legislation and challenging weather conditions described above is a significant motivation for electricity companies to invest and to be involved in impact tool development. Developing the impact tools and raising the self-preparedness of the electricity companies do not only benefit the company, but also indirectly increases the public safety.

2.1.2 Development and implementation

In this chapter we describe the development, method and implementation of the predicting tools to deal with the problem of predicting power outages in an electrical power grid due to hazards produced by convective storms.
The method uses machine learning techniques, such as random forest classifiers and deep neural networks, to predict the amount of damage caused by storms. The goal was to classify storm cells into number of classes, each corresponding to an amount of estimated damage. The classification method use as input features estimates for storm cell location and movement which has to be extracted from the raw data. The main challenges of the method are that the training data is imbalanced because of the lack of extremely severe thunderstorms. In addition, the method requires a large amount of training data (the fault data of the electricity company).

Järvi-Suomen Energia's distribution district is located in South-East Finland, the municipality of South-Savo that is also presented in Figure 5. JSE operates with 27 000 kilometers of transmission lines.

Figure 5: Spatial coverage of the electricity grid information available and the distribution area of Järvi-Suomen Energia. The narrow lines represent the municipality districts and the darker lines the pilot areas power grids. Tervo et al. (2018; 2019)

2.1.2.1 Convective cell identification and classification (Summer tool)

The method used for convective cell identification and classification is explained in details in Tervo et al. (2018; 2019) publication. In this section we explain the main points of the identification and classification.

The convective storm cells are identified by contouring weather radar reflectivity composite CAPPI (constant altitude plan position indicator) images with a 35 DBZ threshold. The contoured objects are clustered and identified as storm (convective cell) objects. The storm cell tracking is done with a time resolution of 5 minutes, 2 hours ahead.

After identifying the storm cells, the convective cells are being classified based on their damage potential. To be able to predict power cuts, storm cells were categorized into four classes based on how much damage they are expected to cause for the power grid. In more detail, the storm cells are assigned to a class based on how large share of transformers under the storm are without electricity. The damage may happen to any point in the grid, but outages are reported in the transformers of the power grid. Thus, the outage prediction is formulated to classify storm cells into one of four different classes, described in Table 1.

Table 1. Class definitions of the storm cells.

Class	Share of transformers
0	No damage
1	0-10 %
2	10-50%
3	50-100%

Two alternative methods were created and tested for classification that are explained in more details in Tervo, (2018, 2019).

The weather data of FMI from years 2012 to 2017 was used as part of the classification. The data contains identified storm cell objects at a time resolution of five minutes. Identifying of the storm objects resulted in 886 020 training samples. The data is imbalanced since the vast of the convective cells are not strong enough to cause harm for the power grid. The training samples were divided to classes as follows: 551 029 samples of class 0 (no harm), 4919 samples of class 1, 4286 samples belonged to class 2 and 3337 in class 3 (most harmful). (Tervo, 2018)

2.1.2.1.1 The user interface of the convective storm tool

The user is able to access the convective storm tool through a FMI's web-based service, (Ilmanet) that is secured with password. We introduce in this chapter briefly the outputs of the tools and explain the functionalities and the meaning for the electricity company. The forecasted route and the severity classes of the convective cells are used the most in the operational center of Järvi-Suomen Energia. The route forecast shows the operator which part of their grid network will be affected in the following hours. Based on this, the operators get more time to plan the placement of the repairing teams. The tool can be used also to identify when it is safe to send the teams to repair the faults. If there are multiple severe convective cells in the area, the route and the severity forecasts help making the decision of whether to send the teams already to the field or whether it is too dangerous. It is also possible to access past cases via the archive function of the tool (Figure 6).

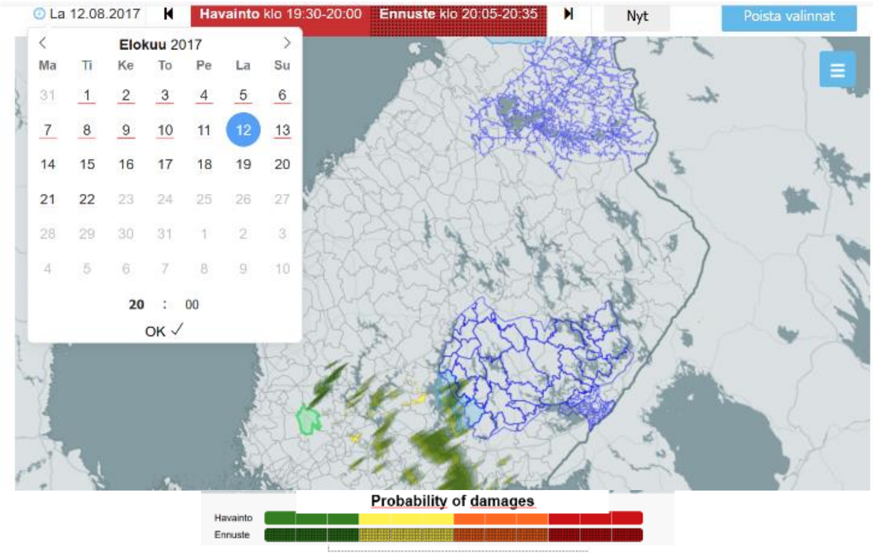


Figure 6: Identified convective cells, the severity of the cell in colors and their route on the map. Archive function for the electricity company to be able to access past cases

The possibility to view a graph that shows the economic impact estimation and energy loss in kWh can be used as a support tool for the communication of the company or for the management. Especially the management needs to deal with cost-efficiency because the company is by law obligated to pay the customers in case of long distribution interruption, in other words; time is money. The more efficiently the operation center can plan the distribution of the resources, the more money the company saves. That is also the reason why the user has the possibility to adjust the values in the tool (Figure 7).

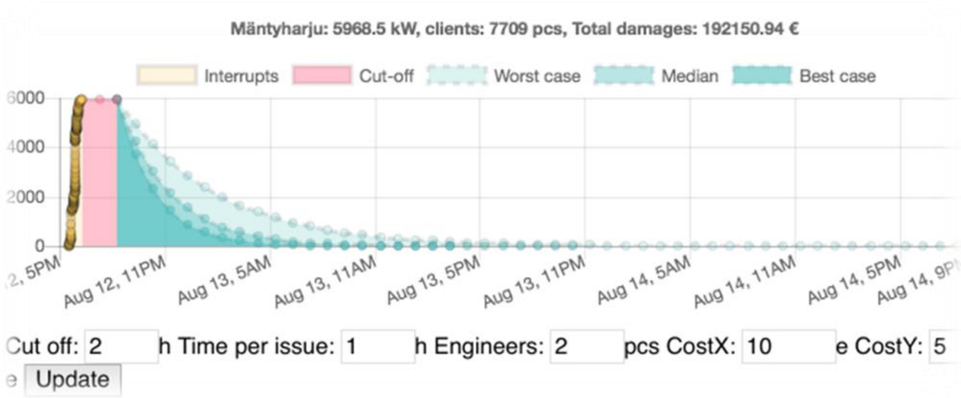


Figure 7: The impact graph that can be opened by clicking on the map. The algorithm calculates the estimated cut off time and estimates scenarios like the worst case interruption duration (x-axis), clients without electricity (y-axis), total damage estimation in Euros and the estimation of the lost energy (kWh) during the interruption. The user is able to change the cut-off time, the time per issue or the number of teams on field that changes also the impact graph.

2.1.2.2 Low-pressure track and intensity identification tool (Winter tool)

The method explained in 2.1.2.1 can be modified and used also for larger scale weather events, like low-pressure storms. The difference compared to the method introduced earlier is that the object is defined based on Numerical Weather Prediction

(NWP) model data instead of radar data. The algorithm is currently being trained with the historical impact and meteorological data (NWP) but also other parameters that are considered to have an impact on trees falling and number of faults in the grid (e.g. the soil moisture and frost, population density and type of the forest.) In Figure 8 the test output of the wind storm tool is presented.

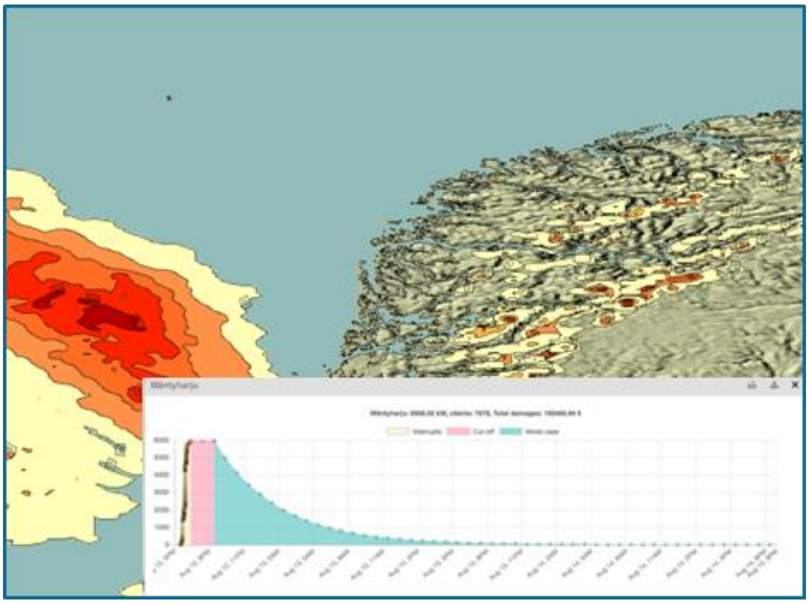


Figure 8: Example of the wind storm tool

2.1.3 Simulations and results

The end users were continuously reporting about the accuracy and bugs of the tool during the testing period. Therefore, the developers were able to fix many problems when identified. During the testing period in 2018 only few thunderstorms occurred on the pilot area, still some promising and valuable feedback on the performance of the tool was received. During the project two trainings for the end users were held before the official training period started in summer 2018. We describe the training activities briefly in 2.1.3.1. Also, a verification on the two different classification methods were examined. The verification of the two classification methods are studied in more details in a method paper of Tervo (2018) and explained in 2.1.3.3 substantially. One case of the summer 2018's most significant thunderstorm day is introduced in 2.1.3.2.

2.1.3.1 Training activities

Two independent trainings were held during the project that are presented in Table 2 The first training was combined held at premises of FMI 24/11/2017 and 15 participants from the electricity companies were able to participate. The training session was a full day training which combined a user training with a feedback session on the convective storm tool. In addition, there were lectures held about weather related hazards and preparedness.

Table 2. Training activities.

Period	24/11/2017	4/5/2018	17/5/2018
WP	WP5	WP6	WP5 & WP6
Activities	1) User training of the convective cell impact tool 2) Strengthening end-users meteorological knowledge	1) User training of A4Finn and A4EU for the civil protection 2) Strengthening end-users knowledge in weather events	1) Training session for the trainers 2) Enhancing the communication between different actors acting in the response with occurring weather events
ANYWHERE tools used	Convective cell impact tool	A4Finn and A4EU	A4Finn and A4EU

The second training was organized at ISTIKE (Eastern-Savo) premises on May 17, 2018 in Eastern-Finland. ISTIKE is the East and South-East Finland's Rescue Services Joint Situation and Coordination Centre. The duty officers of ISTIKE are the main users of MH-EWS tools of ANYWHERE (WP6). However ISTIKE benefits also of the tool introduced in this case study, due the close co-operation between the civil protection and Järvi-Suomen Energia in the regions of Earstern Finland. The training event was targeted to enhance the communication between different authorities and operators acting in the response with occurring weather events. The aim was to train the staff of the electricity company (JSE) and other operator's decision making and improving the co-operation when facing a significant weather hazard or crisis situation. The forecasters of Finnish Meteorological Institute (FMI), an acting duty officer and public relations-person from Järvi-Suomen Energia and civil protection officials were participating to the event. Altogether there were 14 participants. The training was organized in three sections: in the first part, ISTIKE presented their operation, in the second part JSE showed development of the automatization in the outage correction processes and dissemination in the crisis management. The third part included brief instruction to A4Finn manual and the features which are implemented after the last training. An adapted version of ANYCaRE game was organized between parties for training A4Finn and thunderstorm tools of ANYWHERE project.

Figure 9: ANYCaRE- game used to simulate Asta thunder storm event and demonstrate the tools developed in ANYWHERE project

2.1.3.2 Case the 3rd of August 2018

The 3rd of August 2018 was one of the pilot phase's most active day regarding the convective storms in the pilot area. However, the convective activity of the day was not exceptional; Occurrence of similar storm days is around 2-3 times in 10 years. In Figure 10a) are the lighting observations of the day. It can be seen that during the afternoon and in the evening, most of the thunderstorm cells were located in Eastern Finland and on the JSE distribution area. The wind gusts reached locally 15-25 m/s which caused forest damages and also problems on the electricity lines (Figure 10b).

a) b)

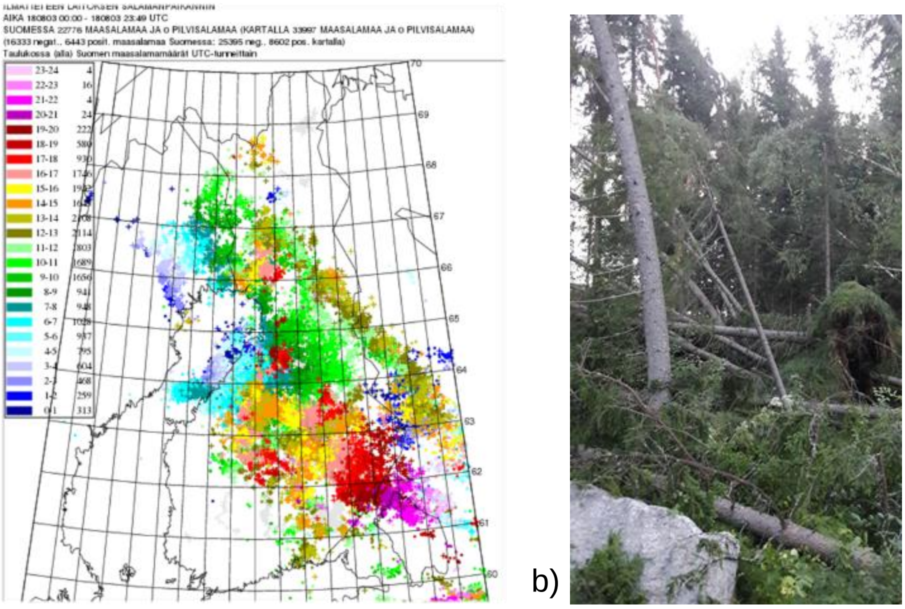


Figure 10: a) 03/08/18 - 22 276 lightning strikes observed with the lighting detection system of FMI and the times of the day lighting took place. b) Wind gusts between 15-25 m/s caused damage for the forest and the electricity grid of JSE

For this case study, JSE provided their interruption data and information about the problems affecting their distribution network. In the afternoon, around 14:30 one thunderstorm cell damaged the distribution network and JSE had to send a repairing team to fix the power line (Figure 11). This was only a minor problem during the day, but the tool managed to identify and classify the cell correctly, and based on oral communication with JSE operators, this saved their time while locating their repairing groups.

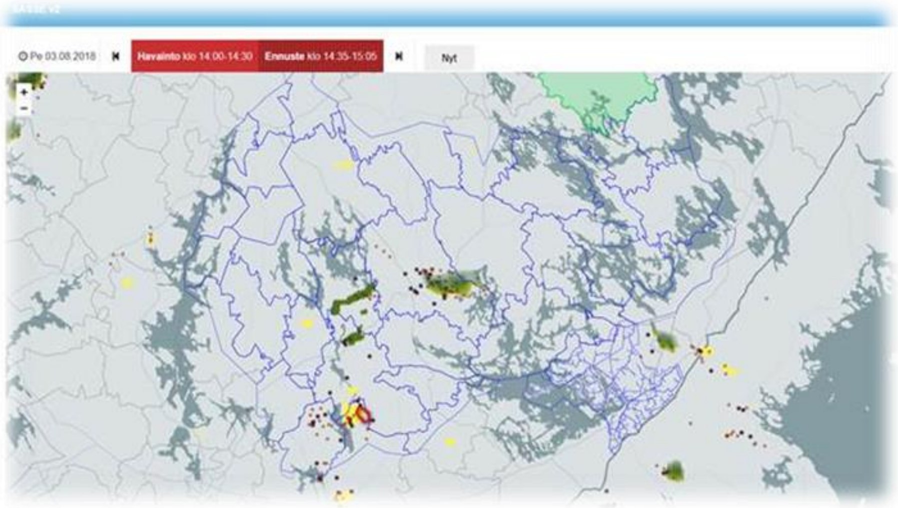


Figure 11: JSE reported a fallen tree on the transmission lines at 14:33 that was caused by the convective cell marked in the picture with red. The algorithm seemed to identify the convective cell object's route and location correctly

At 19:18 there were more thunderstorms in the area and more damage (Figure 12). A downburst related to one of the identified convective caused four trees to fall on transmission lines and damages for 1-10% of the transformers (according to JSE's report). This resulted in approximately 1350 households without electricity while the tool was estimating 1450 households being without electricity (Figure 13 a and b).

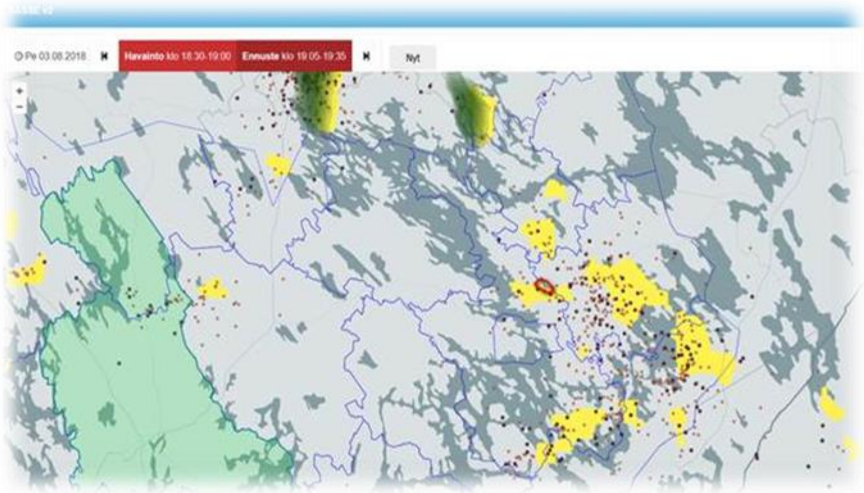


Figure 12: At 19:18 JSE reports a down bust causing four trees falling on the transmission lines on the area marked with red. Also in this case, the tool identifies and forecasts the object correctly and identifies it to be yellow class (1-10% of the transformers damaged)

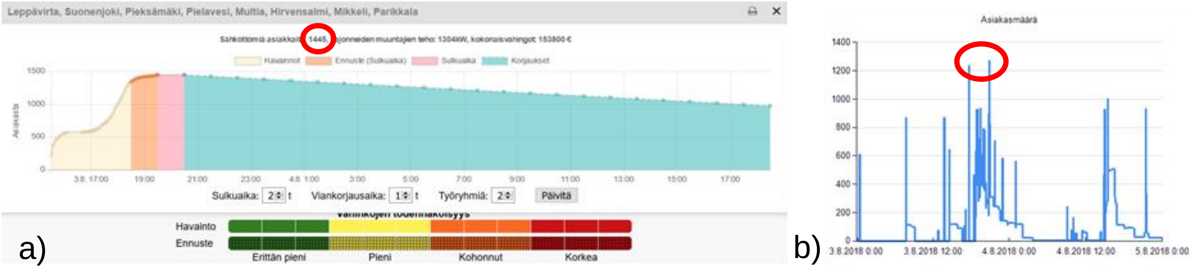


Figure 13: a) The impact forecast estimating 1450 households without electricity after 18:50 on the 3rd of August. b) represents the actual number of households without electricity during the same time (JSE fault system) that were recorded to be 1350 households without electricity..

The biggest challenge during the testing period of the tool was the lack of severe thunder storms. We are aware that case we represent gives a very narrow perspective of the function of the tool. However, in the following subsections we are explaining in more details the reliability of the tool (the verification of the classification method and the user feedback).

2.1.3.3 Verification of the classification method

The two different storm classification methods mentioned in 2.1.2.1 were verified and compared (see Tervo et al. 2018, 2019).

A performance of the first classification method (RFC) seems to be excellent for class 0 (no damage) with over 99 % accuracy and good for class 3 (most harmful) with 87 % accuracy. However, the method has little problems with the storm cells that cause only few damage. The difficulty is in distinguishing classes 1 and 2 as the algorithm tends to underestimate a damage potential of storms. The second classification method (MLP) had significantly worse results in classifying the storms cells and therefore this method was eventually not used in the tool provided for JSE.

Possible error sources and challenges for the method listed:

- Outages may appear in other location where damage has happened
- People density and power grid varies
    - Cities has lots of households but power grid is not so sensitive to weather
    - Accurate information about households and power grid would be needed to enhance spatial resolution
- Classification under or over fits
    - Lots of data but not so many storm cases
- Power grid evolves and changes

2.1.4 User feedback

The user feedback on the tool was collected via personal communication throughout the entire project. Officially, the feedback interviews were done in September 2018, after the official testing period. Järvi-Suomen Energia has 25 employees, of which two were interviewed. The two interviewees were working in different positions and had different roles in the company. The first interviewee was a service expert, customer specialist, who first worked in the control center and who now works with the communication of the company. The second interviewee was a transmission engineer working in the control center.

The interviewees describe the operational environment to be very challenging for the electricity distribution (geographically lots of forest that is vulnerable to the weather events, many lakes, strong winds, etc.). These factors make the preparedness to play a big role in the organization. In daily use, the interviewees mention wind fractiles, -probability and impact forecasting tools forming a significant part of their daily procedure in forming an overall picture on the situation.

The thunderstorm tool was found helpful in the communication center as well as in the operational center of JSE. The tool was used in communication center to provide more accurate information for the public about preparedness via web pages and in the social media. The tool is being interpreted in communication center and the information provided to the public is updated accordingly (for example, the estimation of the length of power cut). Other benefits for the communication center are in general to maintain the same awareness of the situation than the operation center. The role of JSE is not to warn the public so the tool is not used for that purpose, but instead they can warn their own employees on the field from wind or other weather hazards based on the tools. In the operational center the tool helps in decision making when estimating weather it is safe to send technicians to the field to repair transmission lines or if it is still too windy and therefore dangerous for technicians. The tool is used the most when the weather situation seems very severe and the operators want to stay continuously updated of the storm's development. In these cases, the tool provides good situational awareness and estimate on the possible impact and the timing of the storm (the route and the severity of a single convective cell).

The weakest points are related to the reliability of the service and the usability of the interface during the storms. It is not always clear to the end-user does the tool give right values of impact estimation and it is working properly. This is mainly due difficulties and bugs in the first versions of the tool that created a slight distrust. Especially, the visualization of the severity classification had bugs in the beginning that created unreliable feeling. The problems were fixed and the end user is in total satisfied about it. The users also mention that it is easy and valuable to follow the thunderstorm route, but sometimes the impact graph gives unreliable values. If there's a thunderstorm approaching, the operators are extremely busy and updating the tool can take too much time. The estimated customer amounts seem to be close to reality based on user experiences, but the estimated repairing time is seen over estimating the reality.

Future improvements and additions to the tool:

- Number of faults calculated to the whole South-Savo municipality area
- Implementation to JSE's own system instead of an additional web service
- The speed and usability of the interface
- Automatic updating of the interface in every 5 minutes

2.1.5 Identification of Business Case

This section aims to examine the commercial relevance of the products conceived for the current case study, in order to assess the potential for commercial exploitation and the capability of ANYWHERE concept to be sustainable.
Such objective can be reached through by the definition of two steps:

1. Identification of commercial offer to be derived from project results
2. Identification of value proposition for the target users

As first point, a clear identification of the products and services developed and implemented is necessary in order to assess the unique selling proposition. Regarding the capability to reduce storm-driven impacts on electricity transmission grids, there is currently:

- A web service and desktop application to calculate an impact graph in case of thunderstorms (observed/forecasted amount of the customers without electricity, power loss during the disruption in kW and total costs estimation) tested by electricity transmission grid operators.

Working in close cooperation with a relevant stakeholder in providing power supply (i.e. Järvi-Suomen Energia), the solutions have been conceived to fulfil specific needs, framing in this way the value proposition of the service.
Specifically:

- Early (time anticipation) and reliable (exactly where) of weather information (proposition of MH-EWS)
- Flexibility of the methods: meteorological parameters defined as objects so that is possible to combine with different impact data, such as:
  - Heavy snowfall and delays in rail traffic
  - Strong wind and forest damage
  - Flooding and rescue service actions
- Business relevance for impact evaluation: combination of weather information based on historical data (i.e. radar reflectivity, wind, etc.) with operational data (i.e. interruption of service) to give an estimation of economic loss (relevant for business continuity considerations)

To ensure the robustness of such proposition is necessary to identify which is the innovation content in relation to the benefit for customers/users, which paves the way for potential commercial exploitation of the solutions.

In the following a table representing the suitability of the considered solutions to these aspects.

Table 3. Identification of Value Proposition, target users and form for exploitation

Innovation content	Unique proposition: There is no similar tools in Finland (similar solutions exist in US). Combination of weather estimation (convective cells) with electricity interruptions proprietary information: estimation of impact on business continuity (economic losses).
Potential customer/user	Electricity companies, but it is open to any type of customer that may be affected by convective storms.
Benefit to customer/user	Understanding the impact on their infrastructure (estimation of economic loss, electricity distribution interruptions, amount of customer of electricity, estimation of loss of kWh during power break). Severity class of convective cells, route estimation of convective cells.
Relation with ANYWHERE MH-EWS	The algorithm for convective cells is within the MH-EWS (at European level), but the translation into local impact (i.e. economic loss in electricity company) is added by the developed tool.
Potential form for exploitation	Consultancy service; Academic exploitation

2.2 Enabling self-response of the logistic platforms of the food distribution companies during severe weather events

This section describes the solutions to enhance self-response of distribution companies during severe weather events in ANYWHERE by providing a set of tools for the advanced forecasting of the traffic conditions and the simulation of weather-based transport scenarios at different scales, from regional to urban.

The mission is to create a culture of preparedness by using the transport network capacity as self-preparedness enabler, increasing awareness on scenarios affected by weather disruptive events. Improving the visibility of the changes in circulation conditions caused by weather events and its impact transport network capacity means better planning, training, etc., guaranteeing flexibility over multiple users and providing operational benefits for the commercial sustainability and market uptake.

The self-preparedness core capability is related to a service based on the forecasting products served by the ANYWHERE MH-EWS. These are used to forecast the impacts on the circulation conditions that are the main inputs to a logistic platform to enable self-response of logistics companies dealing with distribution tasks (i.e. food distribution companies) during severe weather events.

By cross-correlating the weather forecasts (such as level of snow, precipitation, etc.) and a representative model of the road network, the service is able to estimate the extension of the affected area and the impact on the circulation conditions, which are then translated into the impact on the network capacity. Based on the continuous improvement of weather forecasts as input, the service continuously updates the impact on circulation conditions and simulates and evaluates different transport network scenarios, analysis of the demand assignment, the modal diversion, considering a multi and intermodal supply. The outcome are high-resolution forecasts of the road and circulation conditions, and indications for logistics-related companies (i.e. food distribution) useful to find or choose the best route (i.e. alternative road, multimodal path) between two locations. The platform underlying the service is conceived as support to companies dealing with distribution tasks, without affecting or changing procedures and legacy systems in place.

The support and indications provided by this service is being used by logistics companies to increase their capabilities in planning and safety during high-impact weather situations that can have a negative impact on operational performance. The expectation is that the supply chain entities will be able to lower overall operating costs, create and test newer business models, develop and maintain a higher standard in customer service and attain unsurpassed efficiency (i.e. better shipping options, reduced operational costs, predictive operations, etc.).

The core service is built on a module forecasting the road and circulation conditions from the products supplied by the weather and hazard forecasting products provided by the MH-ES that are used by a macroscale transport chain planner that foresees in input the definition of the demand [one or more Origin/Destination (O/D) matrices in terms of total freight/user movements] and of the supply (a multimodal transportation network represented by a series of graphs of mono-modals and mono-directional oriented links). The procedure of simulation consists in searching the routes (mono- and/or multimodal) that satisfy each O/D relation and to distribute on them, proportionally to the total generalized cost associated with each route, the total flow of the O/D considered, appraising, in this way, the individual modal flows in the transport links, and the transfer flows in the modal interchange (transfer) links.

The following figure shows the architecture of the service.

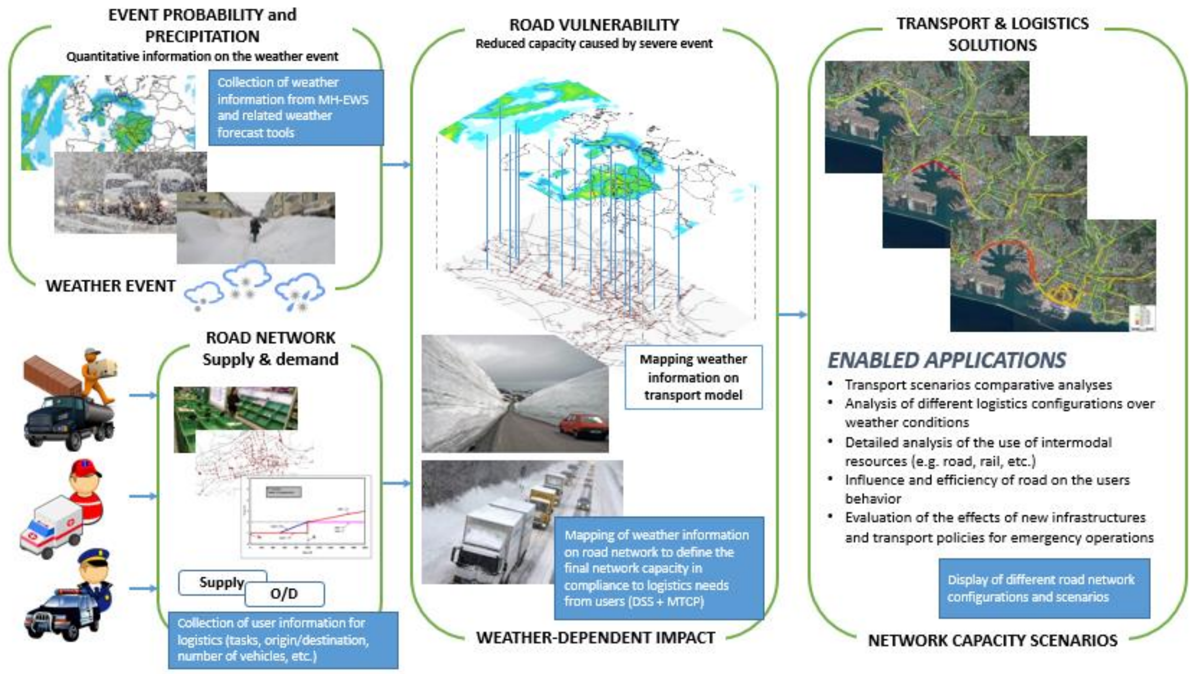


Figure 14: Service architecture

2.2.1 Problem definition

During snow storms or flash floods the road network can be directly affected with a collapse of their capacity (some examples are shown in Figure 15). Due to the occurrence of these conditions, the traffic of vehicles can suffer from reduced performance (i.e. advance of vehicles queues with the increasing of travel time and with the speed reduction), with a high impact on public and private transport services (e.g. bus operation, goods distribution) or on eventual emergency and rescue services (as shown in Figure 16).

To limit the impact of these events, the purpose of Task 5.4 is the development of a tool to support end users whose operations can be affected by the impacts of weather events on the road network. Based on the forecasts of road and circulation conditions, the tools developed in this task enable effective and efficient solutions in assistance of above-mentioned services (e.g. logistic and operation re-planning, reorganization of vehicles fleet, individuation of alternative itineraries, etc.).

Figure 15: Examples of Reduced Capacity of Roads Caused by Snow Storm

Figure 16: Examples of Effects on Public and Private Transport Services

In this context, decisional capabilities can be enhanced by the changes in the application of a transport simulation tool adopted as a calculation engine in support of the decision-making during preparation and planning phase.

Based on the forecasts of road and circulation conditions, in compliance to the logistics user needs (e.g. Origin/Destination) and the road network, the tool simulates and evaluates different transport scenarios and logistic configurations, analysis of the demand assignment, the modal diversion, considering a multi and intermodal supply. The outcome will be scored indications for logistics-related companies (i.e. food distribution) useful to find or choose the best route (i.e. alternative road, multimodal path) between two locations.

The core service has two modules to (i) transform the weather and hazard forecasts into forecasts of the road and circulation conditions, and (ii) a macroscale transport chain planner (MTCP)[1] provided with a dedicated traffic model representative of the road network that models the traffic performance (in terms of flow of road capacity, travel time, speed, queues and routes) in case of high-impact weather events. The MTCP is employed considering the vulnerability of road network consisting in the modification of road capacity (number of vehicles/hours) in function of event entity (e.g. snowfall or rainfall rate, road conditions, etc.).

2.2.2 Weather impacts on the performance of the road network

As described in the paper "*Weather-Responsive Traffic Signal Control*" by Lynette C. Goodwin and Paul A. Pisano (Goodwin and Pisano (2004)), the weather events such as rain, snow, sleet, fog, high winds, and flooding reduce roadway capacity. These events can cause slick pavement, lower traffic speeds, increase speed variability,

[1] The MTCP is developed in DOS and UNIX versions, but released only within the Windows platform

affect traffic volume, increase delay, escalate crash risk, disrupt access to roads and damage road infrastructure

Table 4 lists the impacts of various weather events on roadways, traffic flow and operations.

Table 4. Weather Impacts on Roads, Traffic and Operations (Lynette C. Goodwin and Paul A. Pisano, 2004).

Road Weather Variables	Roadway Impacts	Traffic Flow Impacts	Operational Impacts
Precipitation (type, rate, start/end times)	• Visibility distance • Pavement friction • Lane obstruction	• Roadway capacity • Traffic speed • Travel time delay • Crash risk	• Vehicle performance (e.g., traction) • Driver capabilities/behaviour • Road treatment strategy • Traffic signal timing • Speed limit control • Evacuation decision support • Institutional coordination
Pavement condition (dry, wet, snowy, icy, temperature)	• Pavement friction • Infrastructure damage	• Roadway capacity • Traffic speed • Travel time delay • Crash risk	• Vehicle performance • Driver capabilities/behaviour (e.g., route choice) • Road treatment strategy • Traffic signal timing • Speed limit control
Fog	• Visibility distance	• Traffic speed • Speed variance • Travel time delay • Crash risk	• Driver capabilities/behaviour • Road treatment strategy • Access control • Speed limit control
Wind speed	• Visibility distance (due to blowing snow, dust) • Lane obstruction (due to wind-blown snow, debris)	• Traffic speed • Travel time delay Crash risk	• Vehicle performance (e.g., stability) • Access control (e.g., restrict vehicle type, close road) • Evacuation decision support
Extreme Temperatures & Lightning	• Infrastructure damage	• N/A	• Traffic control device failure • Loss of communications & power services • Increased maintenance & operations costs

Goodwin and Pisano give indications about the capacity reductions according to weather events. For example, on arterial routes, speed reductions can range from 10 to 25 percent on wet pavement and from 30 to 40 percent with snowy or slushy pavement. Average arterial traffic volumes can decrease by 15 to 30 percent depending on road weather conditions and time of day.

The following table shows the data relating to the reduction in speed, traffic volume and capacity as a function of weather conditions.

Table 5. Freeway Traffic Flow Reductions due to Weather.

Weather Conditions	Freeway Traffic Flow Reductions			
	Average Speed	Free-Flow Speed	Volume	Capacity
Light Rain/Snow	3% - 13%	2% - 13%	5% - 10%	4% - 11%
Heavy Rain	3% - 16%	6% - 17%	14%	10% - 30%
Heavy Snow	5% - 40%	5% - 64%	30% - 44%	12% - 27%
Low Visibility	10% - 12%			12%
Light Rain/Snow	3% - 13%	2% - 13%	5% - 10%	4% - 11%

2.2.3 Development and implementation

A real-time forecast module (Road conditions forecasting module) was designed and developed in order to determine the effect of weather events on the roads conditions. To achieve it, the module uses the forecasts available in the MH-EWS.

A specific software tool (SW tool) has been developed with the aim of interface the Road conditions forecasting module with the Macroscale Transport Chain Planner (MTCP) and respond to the requests of information made by the Decision Support Tool (DST - developed in the framework of WP4), about the weather impacts on roadways, traffic flow and operations.

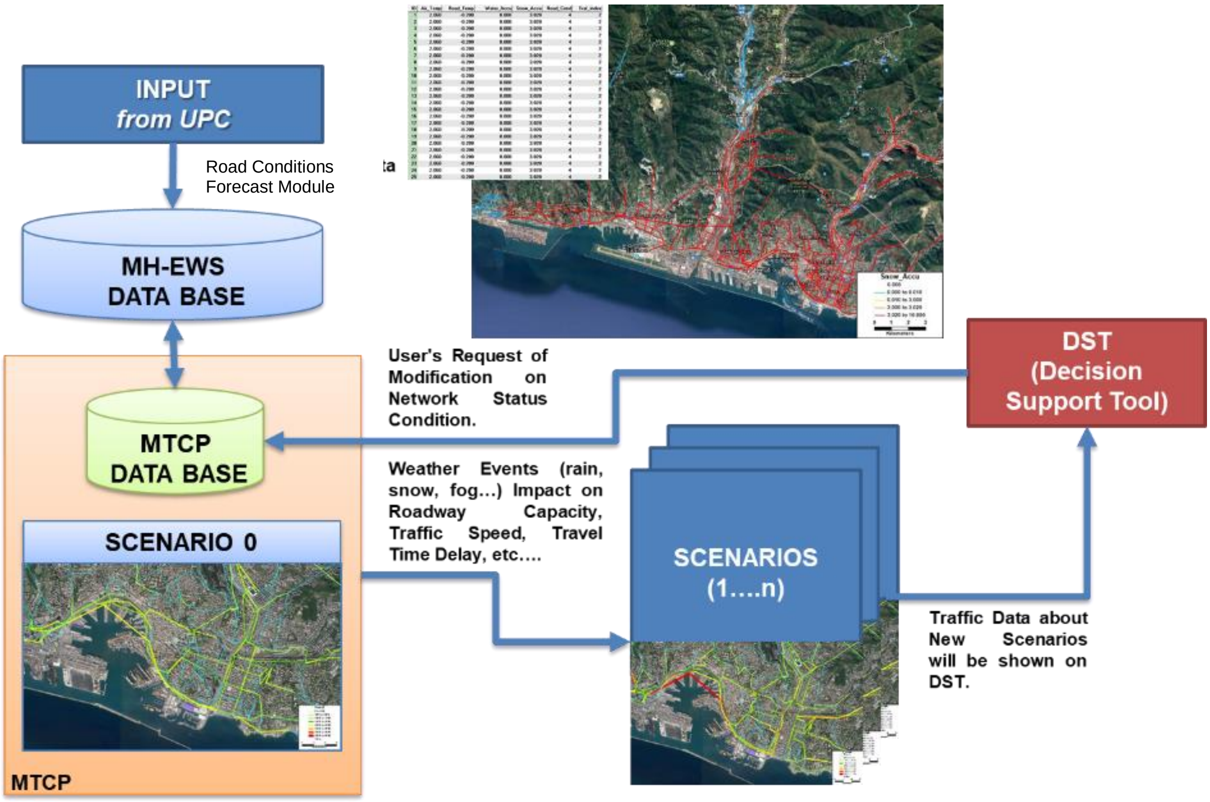


Figure 17: Tool Process Workflow

The tool is a RESTful application developed

- to elaborate the DST simulation request,
- to process the Weather forecast information and update the Road Arcs parameters (Capacity and Speed),
- to run a the current MTCP simulation as well as,
- to provide the new traffic condition to the DST through the local area network via GEOJson formatted data,

and an Apache Tomcat application server to provide runtime support to all the connected users.

Table 6. Tool information flow.

Tools involved	Input	Output
DST	-	Simulation request
SW Tool	Simulation request Weather forecast	Updated road network information
Macro Transport Chain Planner (MTCP)	Updated road network information	New traffic condition
SW Tool	New traffic condition	Traffic condition (GEOJson formatted data)
DST	Traffic condition (GEOJson formatted data)	-

Table 7 shows the metrics defined to update the road network information, in terms of the road arcs parameters as such as capacity and speed, based on weather forecast (Road Condition), implemented within the SW Tool.

Table 7. Vulnerability function.

Road Condition	Capacity Reduction	Speed Reduction	Notes
Dry	0%	0%	
Slightly wet	10%	6%	Min Values due to Heavy Rain Reduction
Wet	30%	17%	Max Values due to Heavy Rain Reduction
Water & Snow	11%	13%	Max Values due to Light Rain/Snow
Little Snow	12%	5%	Min Values due to Heavy Snow Reduction
Snow	27%	64%	Max Values due to Heavy Snow Reduction

The tool allows the DST to elaborate three Condition of Simulation request, as shown by the table below.

Table 8. Simulation Request.

Condition	Traffic simulation result
Normal	Standard traffic flows
Forecast	Diverted/rerouted traffic flows due to forecast road condition
What if?	Diverted/rerouted traffic flows due to road closures

2.2.3.1 Road conditions forecasting module

In order to support the decision-making of food distribution companies by anticipating the expected road and traffic conditions during high-impact weather events (specifically snowfall) a real-time forecast module have been designed and developed. This road conditions forecasting module determines the effect of the weather event by means of two indexes to assess the ease of circulation and the road conditions for each stretch of the road network (Figure 18). Hereafter, they are referred to as the circulation index and the road conditions index.

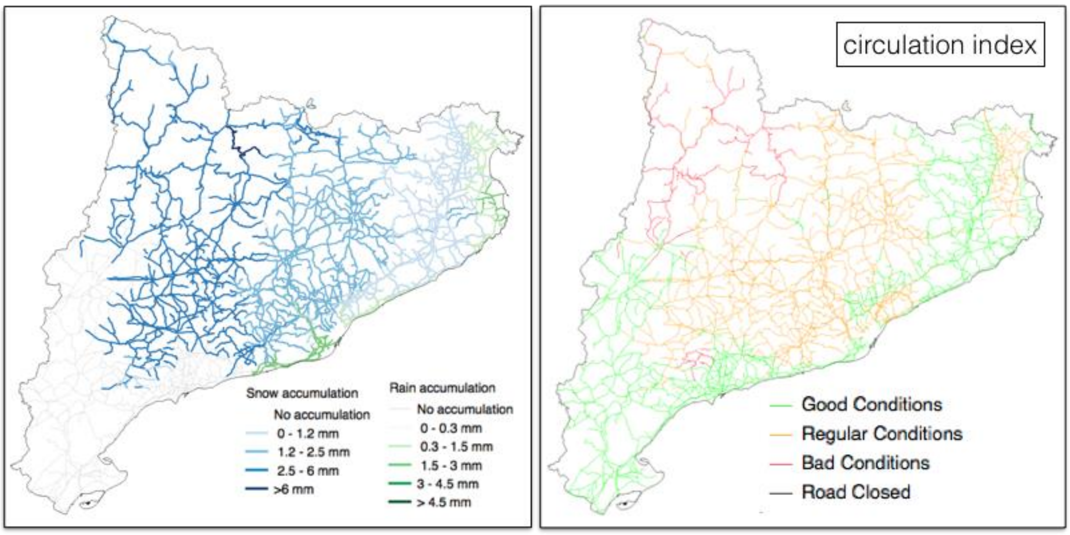


Figure 18: Snow impacts on the road network of Catalonia on 28 February 2018 at 0700 UTC. Left: water accumulated on the road surface; right: circulation index.

The Road Conditions Forecasting Module translates weather observations and forecasts to the impact on roads and circulation conditions. To achieve this, the module collects the forecasts available in the MH-EWS and uses them as inputs of a 1D energy balance model, which predicts road surface conditions based on modelling the energy fluxes at the ground surface. Currently, this module can run with the forecasts of FMI HIRLAM and ECMWF IFS NWP models.

The module is customized to the needs of the end-user (e.g. food distribution logistics platforms), it is integrated with the ANYWHERE MH-EWS and, in addition, on the Catalonia Pilot site (Figure 19), demonstrating its potential transferability to other applications.

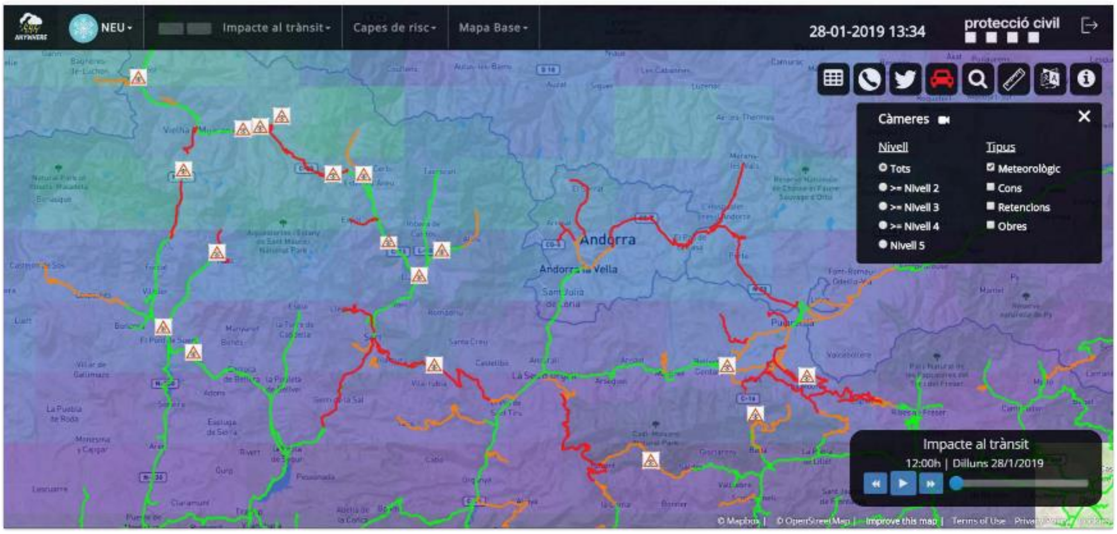


Figure 19: Example of the circulation conditions index integrated in the A4CAT platform.

The tool has been tested with historic events in both Catalonia and Liguria (Figure 20) and has been working in real time since autumn 2018, using NWP weather forecasts supplied by the ANYWHERE MH-EWS.

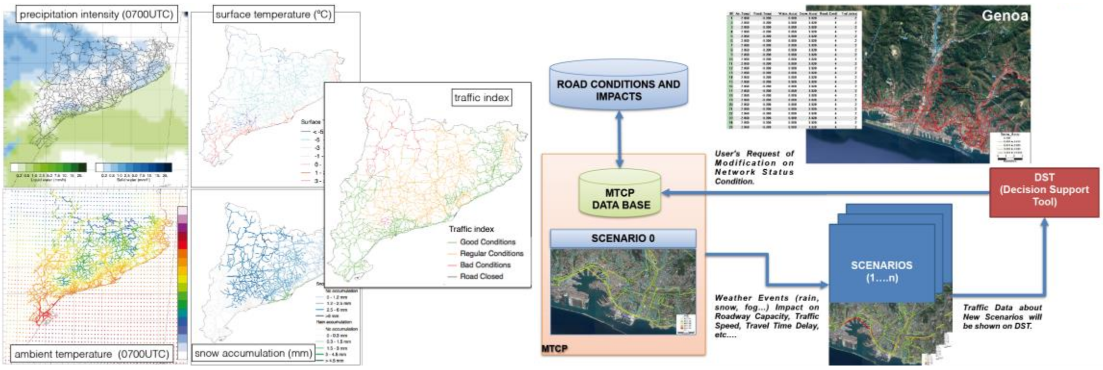


Figure 20: Integration of algorithms for (a) snow accumulation and traffic index with (b) decision support tool for routing of food logistics.

2.2.3.1.1 Conceptual Framework

Figure 21 shows the proposed conceptual framework for the road conditions forecasting module.

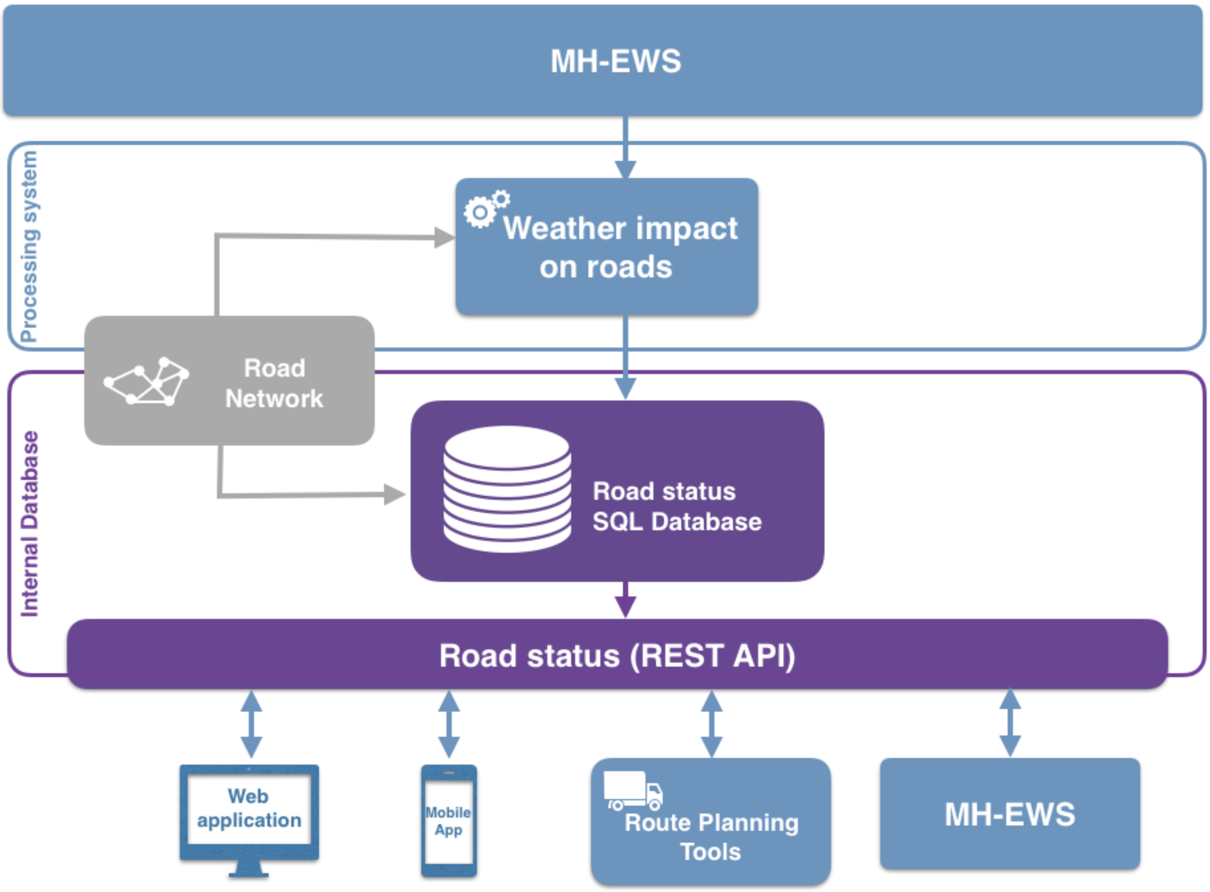


Figure 21: Conceptual Framework of the set up for the tools to support logistics platforms during high-impact weather events.

The starting point is the **MH-EWS**, a framework that integrates both the forecast and hazard models developed within ANYWHERE and the existing Pan-European platforms. The developed Road Conditions Forecasting Module uses as inputs the forecasts of several variables obtained with the ECMWF IFS NWP model.

These variables are used by the **Weather impact on roads** module, which is composed of a 1D energy balance model that predicts road surface conditions based on modelling the energy fluxes between the atmosphere and the road surface. The necessary inputs are both the NWP models and the road network. As output the module forecasts the conditions of the road surface, expressed as the road temperature and the amount of accumulated water (either in the form of liquid water or snow).

For each scenario/case study a **road network** is necessary. Multiple instances can be run in order to forecast impacts on different network roads. The network road is expected to be in ESRI Shapefile (SHP) format, a geospatial vector data format for geographic information system (GIS) software. It can define vector features, which have attributes describing them.

The forecasts of the road and circulation conditions on each stretch of the road network are uploaded in a **SQL database** in order to make them available through the Road conditions **REST API**. REST (Representational State Transfer) is a software architecture style for data exchange between different modules using the Hypertext Transfer Protocol (HTTP) communication protocol, providing interoperability between systems on the Internet.

Different **applications** can access the forecasts stored in the Road Conditions SQL Database through the Road conditions REST API described above. This approach allows to design specific Web Applications or Mobile Apps, or to connect with Route Planners tools that can query the road and circulation conditions in a given stretch of the road network and to the generated alerts at a given time step.

Finally, the forecast shapefiles are deployed and made available through the MH-EWS.

2.2.3.1.2 1-D Energy Balance Model on the road surface

The model used to forecast the road conditions is similar to existing road weather forecasting models such as RoadSurf (Kangas et al., 2015) or Metro (Crevier and Delage, 2001). A full description can be found in Huertas (2019). As input, the model employs numerical weather forecasts and in principle it could also use observations form weather stations and precipitation from radar measurements. The output is the conditions of the road surface (both surface temperature and road surface and circulation conditions).

The model is run with a time step of 1 h with a maximum lead time of 48 hours and every time new NWP forecasts are available (every 12 hours).

The algorithm needs 9 inputs that are obtained from the IFS forecasts of atmospheric variables supplied by the MH-EWS: Geopotential Height, Humidity, Precipitation, Pressure, Radiation, Temperature, Total cloud cover and Wind speed (see Figure 22).

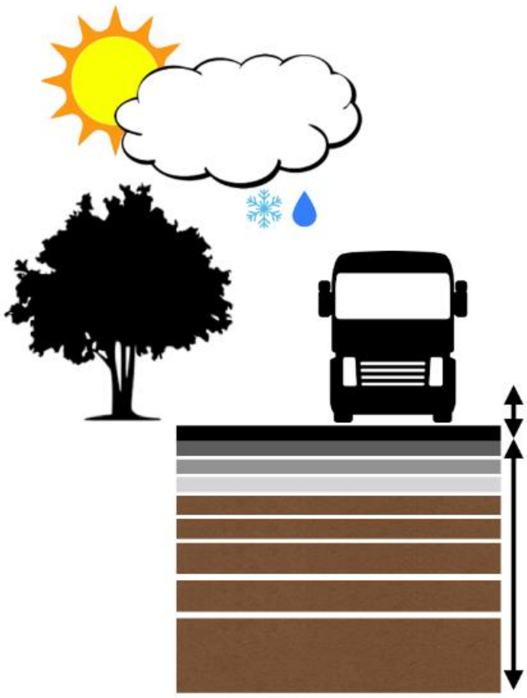


Figure 22: General scheme of the process accounted for the 1D energy balance model used to forecast the conditions of the road surface.

2.2.3.1.3 Case study

From the very early morning on the 28 of February 2018 a snow storm affected a good portion of Catalonia (NE Spain), specially moving down to near the coast, where some of the main roads of the network are located. Based on the weather forecasts, the Civil Protection authorities took the decision to close the main road network to trucks traffic on the 27 February 2018 at around 1800 UTC, and stopped a large number of trucks in the parking areas of the highways.

This event has been chosen to illustrate the products generated by the energy balance model on the road surface (see section 2.2.3.1.2). Figure 23 shows the fields of precipitation intensity, atmospheric temperature and road surface temperature on the road network of Catalonia at 0700 UTC on the 28 February 2018. The main outputs of the model in terms of road surface and circulation conditions are summarized in Figure 24.

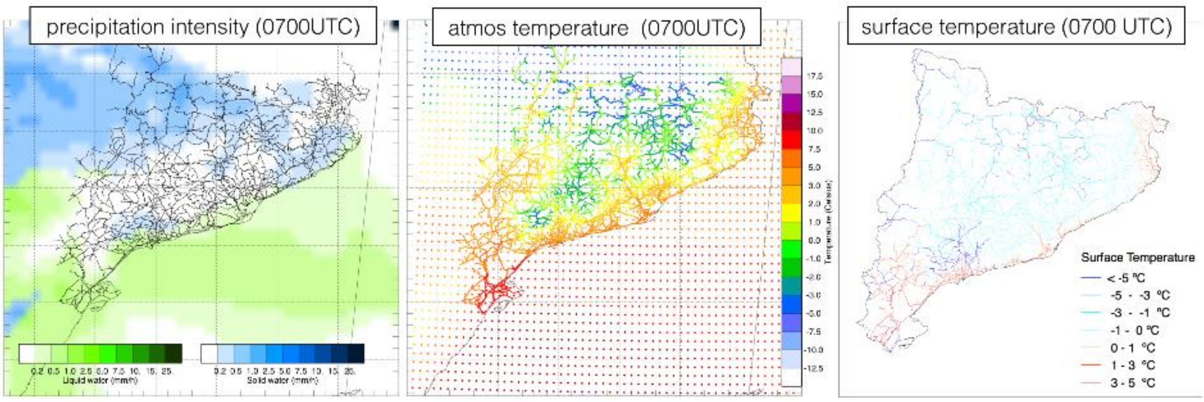


Figure 23: Forecasts obtained with the snow accumulation model on the road network of Catalonia on 28 February 2018 at 0700 UTC. Left: Precipitation intensity and phase; center: atmospheric temperature at surface level; right: road surface temperature.

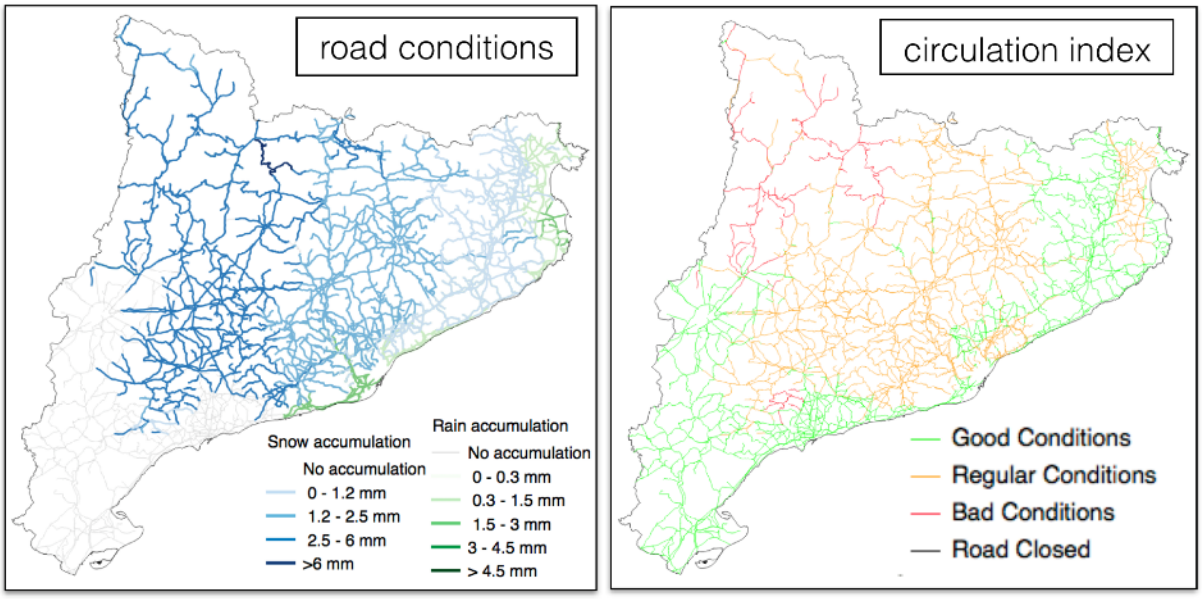


Figure 24: Forecasts of the obtained with the snow accumulation model on the road network of Catalonia on 28 February 2018 at 0700 UTC. Left: Water amount and phase accumulated on the road surface; right: circulation index.

2.2.3.1.4 End-user adapted solution

In this case study, the end user is the Council of Food distribution Companies of Catalonia (CEDAC), represented by one of its associates. Once the Energy balance model on the road surface was set up, the end user was incorporated into the process to develop a tool adapted to its needs.

In collaboration with CEDAC, the needs to be covered by the application were analysed from the point of view of coordinators of truck fleets, and the tool was developed and tested in their operations throughout winter 2018-2019.

The tool was designed as a web display, the Road Condition Viewer. The main use cases of the web are:

- To show the surface and circulation conditions (current and forecasted) on the road network for the area of Catalonia.
- To show the status (current and forecasted) of a set of selected supermarket shops and suppliers, considering a given set of main regional routes and the nearest access roads to them.
- To list the forecasted alerts, considering the affected roads, the beginning and ending times of the affectation.
- To receive, via e-mail, a notification alert summarizing the forecasted alerts affecting the monitored centres. The user can define some configuration parameters such as the routes or the time to receive notifications by e-mail.

The Road Conditions API and Viewer were designed and developed based on these requirements.

2.2.3.1.5 Road Conditions API

After the 1-D Energy Balance Model generates a new forecast, the outputs (summarized in a SHP file) are sent to an internal API that stores the forecasts into the SQL database, and calculates the alerts for each of the roads links. For each road, an alert is created for each time interval in which it is affected. There are 4 levels of road conditions:

- Good conditions (no alert)
- Bad conditions
- Hard conditions
- Road closed

After the alerts for the road network have been computed, the alerts for the monitored centres are calculated. To create an alert for a centre, a main access road (according to the information provided by the end-user) or a road within a radius of 10 km from the centre needs to have also an alert generated. After that, the starting and ending timestamps for each alert are calculated, and stored into the database.

Finally, a set of endpoints (listed in Table 9) have been defined in order to provide access to the information for the designed Road Conditions Viewer to support logistics platforms under high-impact weather conditions. An example of the end point /api/alerts is provided in Figure 25.

To provide secure access to the services offered by the API, they are accessible only to authorized users. A user token needs to be used in all the calls to the API functions.

Table 9. API endpoints description.

URL	Description
/api/graphs/	Provides information about the different road networks included in the system.
/api/graphs/{name}/	Provides information about the given cartography (graph)
/api/graphs/{name}/links/	Information of all the links of the given cartography
/api/graphs/{name}/links/{id_link}/	Provides all the information of the given link
/api/alerts/	List of road alerts (monitored centers and road sections included)


```
{
    "date_ini": "2018-02-27T01:00:00Z",
    "date_fi": "2018-02-27T03:00:00Z",
    "Traf_Index": 3,
    "next_Traf_Index": 2,
    "road": "A-2",
    "zone": 23
},
{
    "date_ini": "2018-02-27T01:00:00Z",
    "date_fi": "2018-02-27T03:00:00Z",
    "Traf_Index": 3,
    "next_Traf_Index": 2,
    "road": "AP-7",
    "zone": 23
},
{
    "date_ini": "2018-02-28T10:00:00Z",
    "date_fi": "2018-02-28T16:00:00Z",
    "Traf_Index": 3,
    "next_Traf_Index": 2,
    "road": "B-300",
    "zone": 23
},
```


Figure 25: Response example for endpoint /api/alerts.

2.2.3.1.6 Road Conditions Viewer to support logistics platforms of food distribution companies during high-impact weather events

As mentioned above, together with the user-adapted daily alerts that are sent by e-mail, the evolution of the state of the defined routes can be followed through the Road Condition Viewer, which has been designed following the end-user requirements. Access to this web-based viewer requires authentication to guarantee the security and privacy of the information provided by the end user regarding the routes to access the shops and the main suppliers (Figure 26).

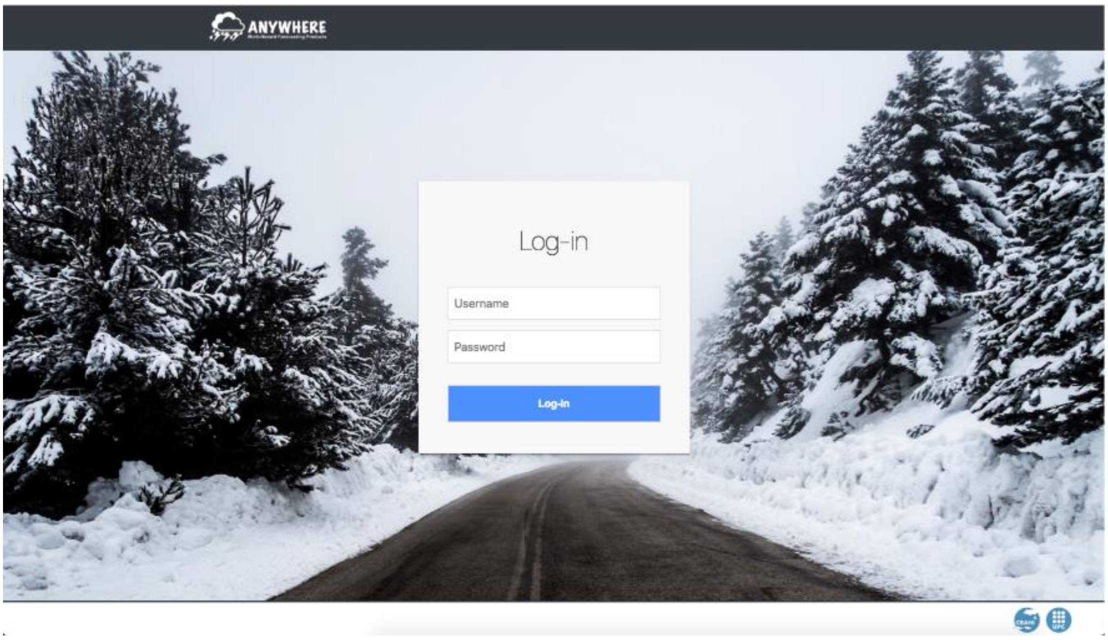


Figure 26: Login page of the road Conditions Viewer developed for the logistics platform end user.

Once the access to the web page has been granted, the main page displays the most recent information on the state of the road network and the alert level for all centres monitored at the current moment (Figure 27).

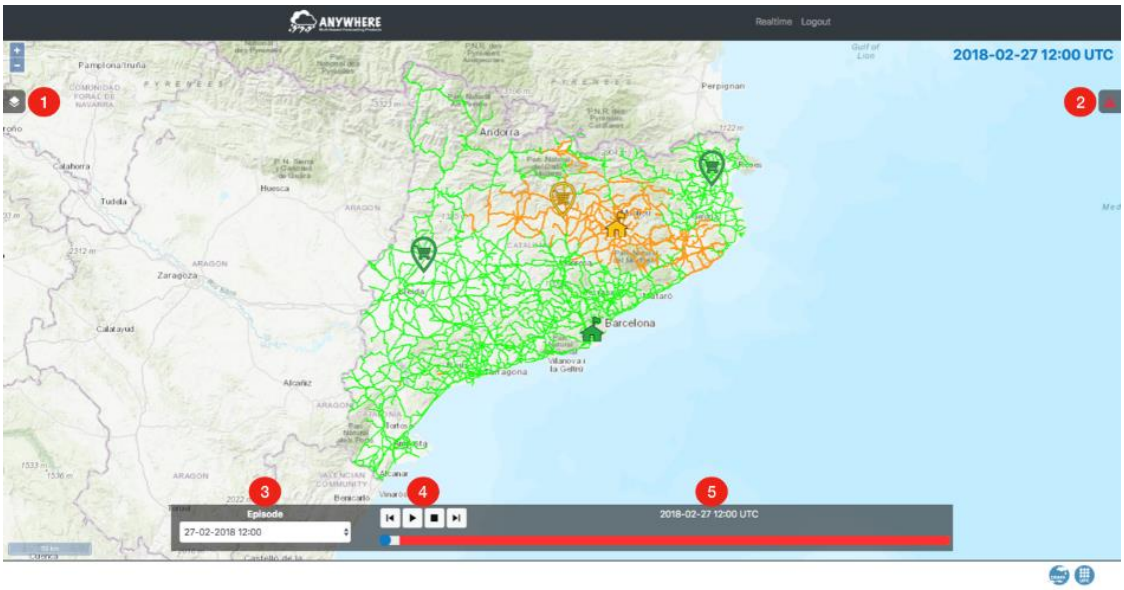


Figure 27: Main page of the Road Conditions Viewer developed for logistics platforms.

The colour of the roads corresponds to the current conditions, differentiating between 3 levels: unaffected (green), moderately affected (yellow) and severely affected (red). For the centres, the colour corresponds to the worst forecast from the selected moment to the end of the forecast. The iconography chosen (defined in Table 10) differentiates between shops and suppliers, indicating the degree of affectation with the chosen colour code.

Table 10. Iconography of centres.

Icon	Center Type	Degree of affectation
	Supplier	No affectation
	Supplier	Moderately affected
	Supplier	Severely affected
	Shop	No affectation
	Shop	Moderately affected
	Shop	Severely affected

On each side of the main web page (Figure 27) there is a drop-down menu. The left menu (1) allows the user to select between the different layers of information that the tool incorporates, while the right menu (2) lists all the current alerts. The icon indicates the expected maximum alert level.

Finally, the time control panel is available at the bottom. This panel has a scroll bar to advance over the forecasts. With the playback controls (4) you can also advance step by step or play a loop animation. The time of the selected forecast is displayed in (5). In addition, a past event selector (3) has been added.

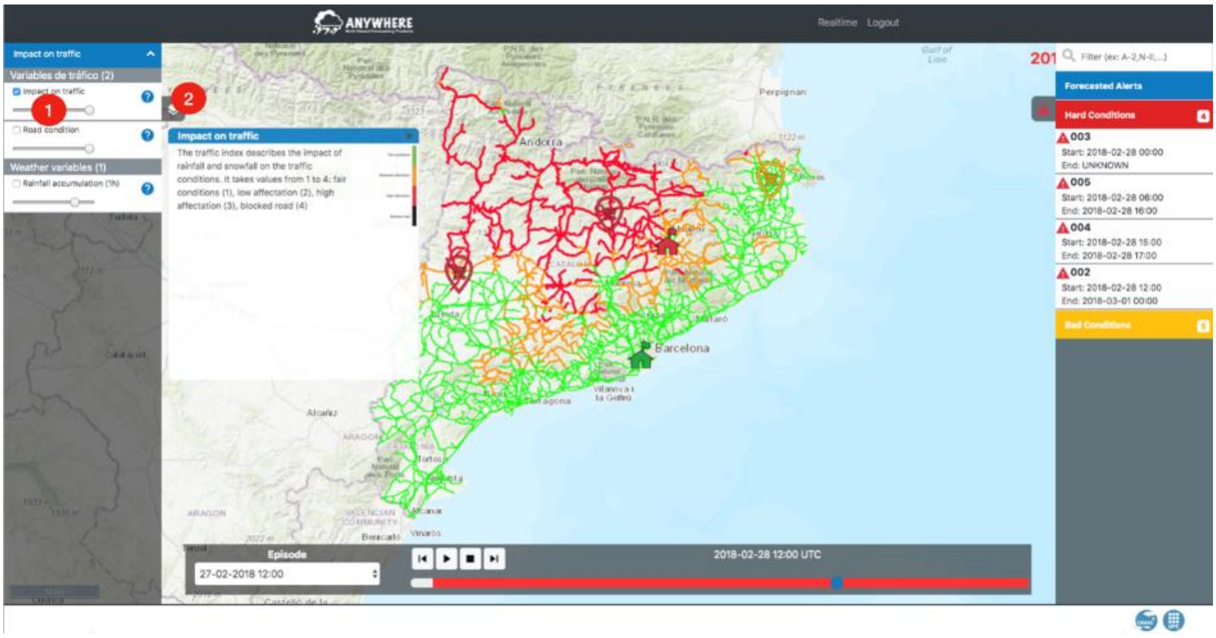


Figure 28: Detail of the sidebars.

Figure 28 shows the two displayed menus. The products sidebar (left menu) is divided into two groups: the first group (Traffic Variables) includes road condition forecasts and the second (Weather variables) includes weather forecast layers.

For each of the products the scroll bar (1) allows the user to adjust the opacity of the layer and the question mark icon (2) opens the description and colour scale of the layer.

The products provided in current version are:

- Impact on circulation conditions.
- Road condition: State of the road (dry, wet, snow, frost, etc.).
- Rainfall accumulation (1h): Rainfall accumulation observations and nowcasts (up to 6 hours) based on European radar observations.
- Precipitation: 48-hour Precipitation Forecast.
- 2-meter Temperature: 48-hour Temperature Forecast.
- Precipitation type: 48-hour forecast of the most probable precipitation type (rain, snow, etc.).

Finally, the Viewer allows the user to select each of the centres and displays additional information in a drop-down list (Figure 29). In this drop-down window, in addition to the name of the centre, both alerts based on the defined access roads and alerts calculated on the basis of the state of the roads within a radius of 10 km are displayed.

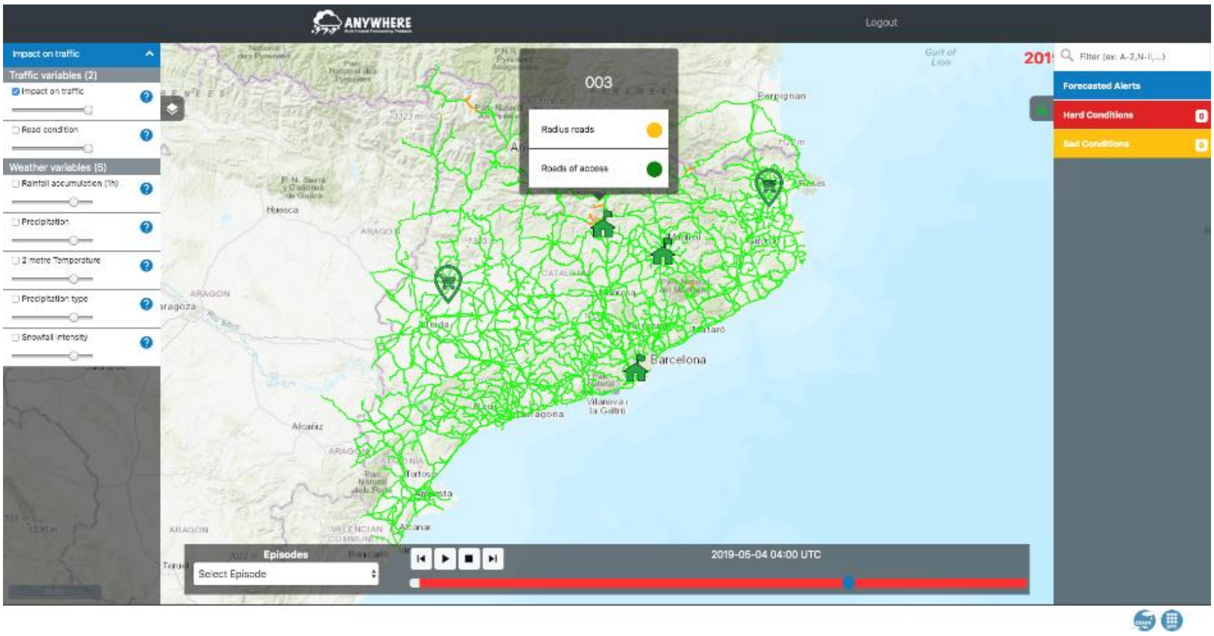


Figure 29: Information displayed when selecting a site.

An administration intranet has been implemented to ease the definition of centers and related roads. The main view of the intranet is shown in Figure 30.

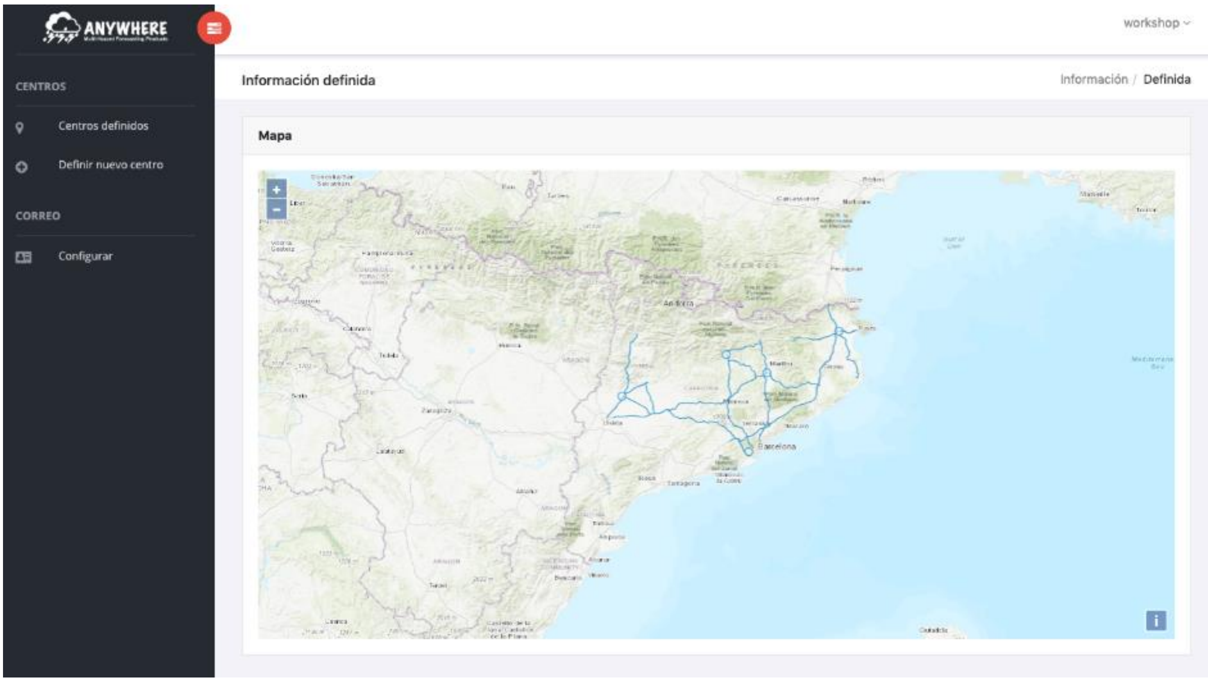


Figure 30: Site-administration intranet for the Road Condition Viewer.

Any user with administration credentials can browse the list of defined centres (Figure 31) and is allowed to delete or modify them or add a new one.

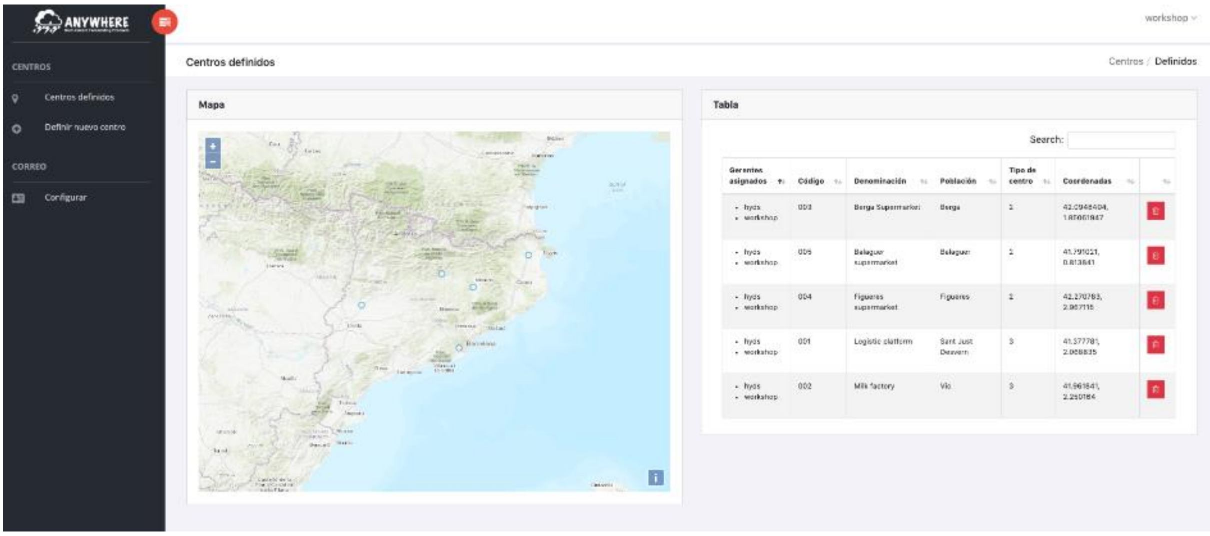


Figure 31: List of the defined center in the administration page.

Defining a new centre consists of providing its basic information (centre code, name, town), selecting the type of centre it is (shop or supplier) and indicating its coordinates for its correct geolocation (as shown in Figure 32). User can also define the main access routes, which are used to calculate the alerts that may affect the centre.

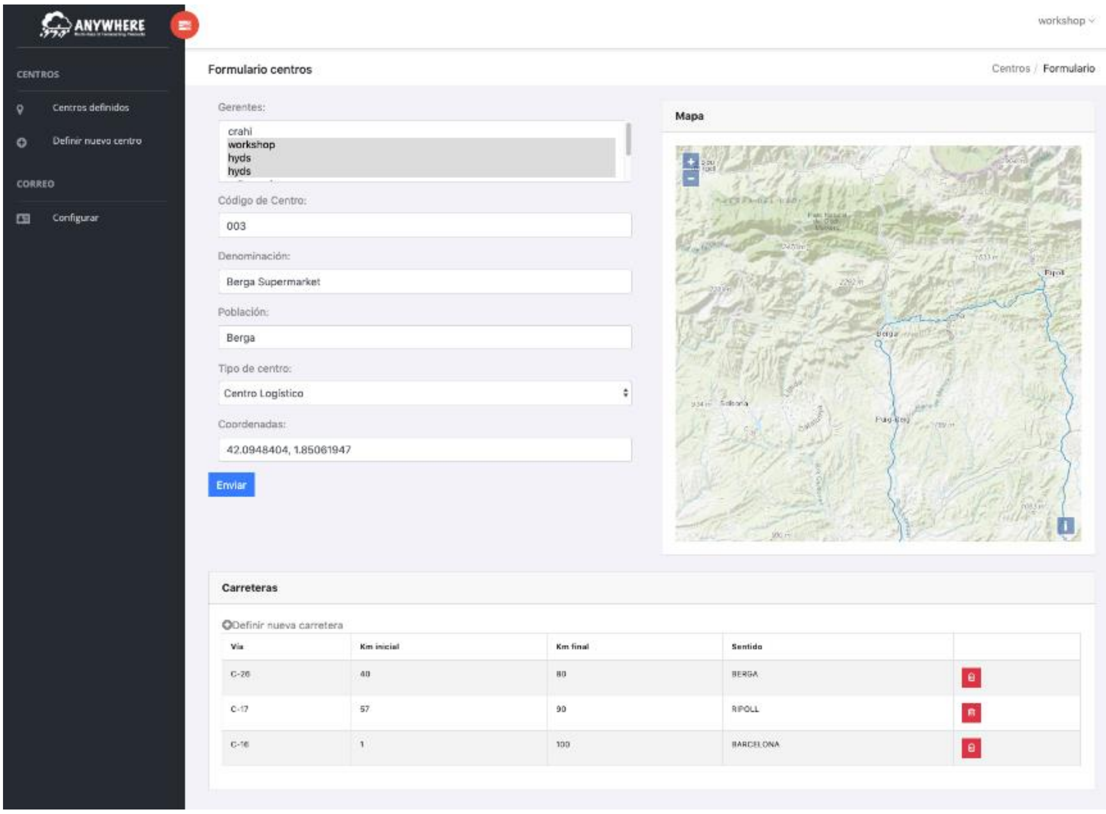


Figure 32: Definition of a new centre.

2.2.3.1.7 Transferability to other platforms

The module to forecast road and circulation conditions is flexible and can be set up in new road networks with moderate. The integration of the outputs of the module to display its information is quite straightforward effort, because they are available through the ANYWHERE MH-EWS.

This enabled the application of the Road Conditions Forecasting Module in new locations and integrate its outputs of beyond the end-user solution described in section 2.2.3.1.4. In this regard, some exploratory works to use this framework for other applications have been carried out.

A clear example of this is the inclusion of this product into the A4Cat platform. The forecasts have been available for the Department of Interior of Catalonia during all the winter 2018-2019 campaign (Figure 33). As a result of this experience, some additional features have been asked to be included for the next campaign (alerts for critical roads and points, for priority roads and for school transportation routes).

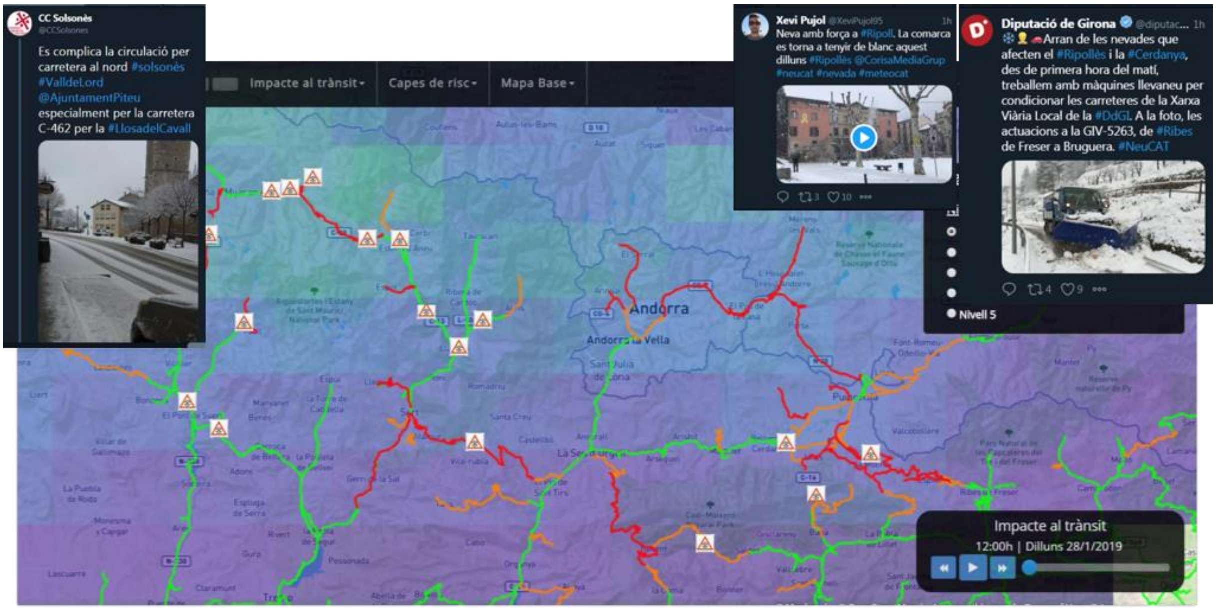


Figure 33: Road condition forecasts integrated with A4Cat.

Recently, a new case study related to the snowplow management in the area of the Parque Natural de Cazorla, Segura y las Villas (Jaen, Spain) has been tested by the request of the Department of Environment of the Regional Government of Andalusia.

The tool was tested during the snow event that affected this area on 05 April 2019 (Figure 34), and the results showed that 48 hours in advance it would have been possible to anticipate a snow episode with impact on road conditions, and 24 hours in advance the simulations consistently anticipated the start time of the affectation.

Figure 34: Road Condition Forecast in the region of Jaen on the 05 April 2019 at 1100 UTC

2.2.3.2 Macroscale Transport Chain Planner (MTCP)

Traffic simulation on the road network is carried out using the MTCP traffic simulation software.

2.2.3.2.1 MTCP input data definition

In MTCP, the road network is made of a set of “mono-directional” and “mono-modal” oriented links (in accordance with the graph theory). A link is defined by its two nodes of extremity, sequentially provided according to the orientation of the link. The mode is univocally indicated by a symbol of one character (ex.: a b f s ...) for links of transport, of two characters for links of modal interchange or transfer (ex.: ab fs ….) and of two characters, one of which is an asterisk *, for the fictitious links (ex.: *a, s* …).

The necessary information to develop the road network model, adopting MTCP tool, consists of two categories:

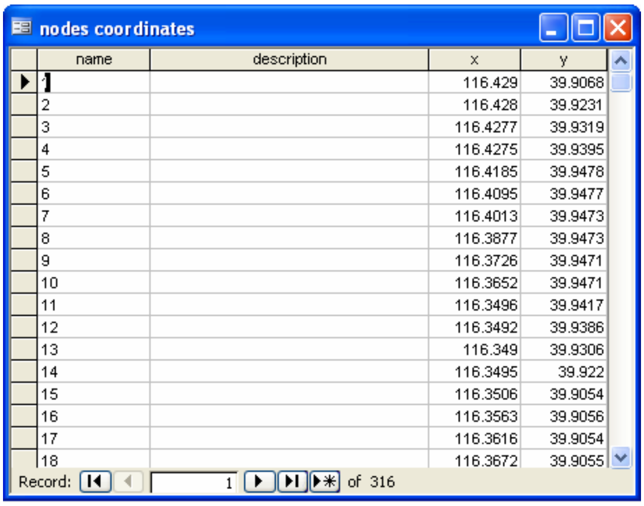
- Nodes Coordinates;
- Net Links Development.

Nodes Coordinates

In accordance with a geographic reference system adopted in a GIS, the necessary data input for all the Nodes are:

- ID node;
- Coordinate X;
- Coordinate Y.

The nodes are registered in a dedicated database as reported in Figure 35. An example of road network nodes representation is reported in Figure 36.


nodes coordinates

name	description	x	y
1		116.429	39.9068
2		116.428	39.9231
3		116.4277	39.9319
4		116.4275	39.9395
5		116.4185	39.9478
6		116.4095	39.9477
7		116.4013	39.9473
8		116.3877	39.9473
9		116.3726	39.9471
10		116.3652	39.9471
11		116.3496	39.9417
12		116.3492	39.9386
13		116.349	39.9306
14		116.3495	39.922
15		116.3506	39.9054
16		116.3563	39.9056
17		116.3616	39.9054
18		116.3672	39.9055

Record: 1 of 316

Figure 35: Nodes Coordinates Data Base

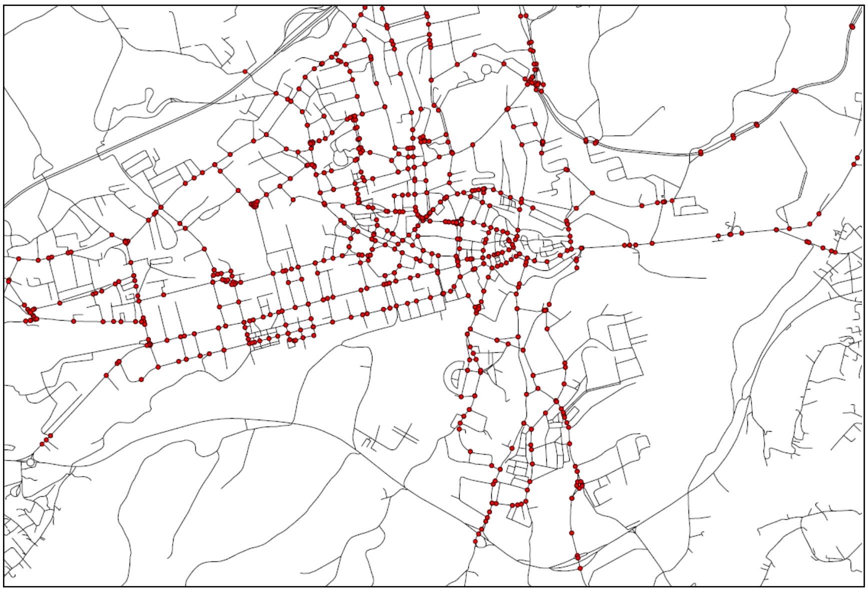


Figure 36: Example of Road Network Nodes Representation

Net Link Development

The information to be considered to complete the development of road network representation model (travel graph), managed by MTCP with dedicated data entry window and database are:

- Name of link;
- Description of link;

- Start node;
- End Node;
- Link Modal Type (string of characters that identify one or more transport modes for the link);
- Opposite link generation;
- Link Length (data not used in case of correct node coordinates);
- Link crossing time (for transport and fictitious links is the design time/maximum speed to cross the link, i.e. the time with null flow. For modal interchange links, is the transfer time or for modal interchange);
- Transfer time (only for modal interchange and fictitious links);
- Monetary Extra Cost (monetary extra-costs due to the crossing of the link of a unit of freight/user);
- Delay Coefficient (variation of the link crossing time for the calculus of the medium delays);
- Capacity of the link (number of vehicles that can pass in 1 hour);
- Alfa-Beta (parameters of relationship Flows-Time).

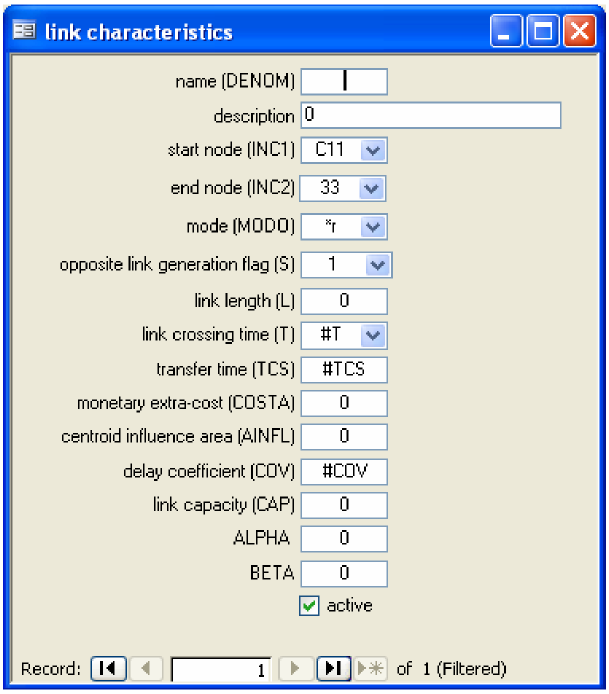


Figure 37: Links Data Entry

links characteristics

filter on transport links: all modes
filter on fictitious links
filter on interchange links

NAME	DESCR	INC1	INC2	MODE	S	L	T	TCS	COSTA	AINFL	COV	CAP	ALPHA	BETA	active
		AG	AG	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AL	AL	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AN	AN	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AO	AO	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AP	AP	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AQ	AQ	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AR	AR	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AT	AT	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		AV	AV	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		BA	BA	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		BG	BG	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		BI	BI	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		BL	BL	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑
		BN	BN	*s	1	0	#T	#TCS	0	1	#COV	0	0	1	☑

Figure 38: Links Data Base

Additionally, a further important information need to be assigned on the road network representation model: the O/D Matrixes, where the information required is structured as follows:

- Matrixes Origins (Macronode i-th)/Destinations (Macronode j-th).

2.2.3.2.2 MTCP output data definition

The results produced by MTCP after the assignment of the matrixes to the road network representation model are:

- summary of total flows for all links in the net, per type of freight/users and the totals, as well as the time and the equivalent costs;
- for each assigned O/D relation, this result includes the definition of all the routes in which the flow is distributed and, for each route, additional values relevant to the costs and to the travelling/transfer times.

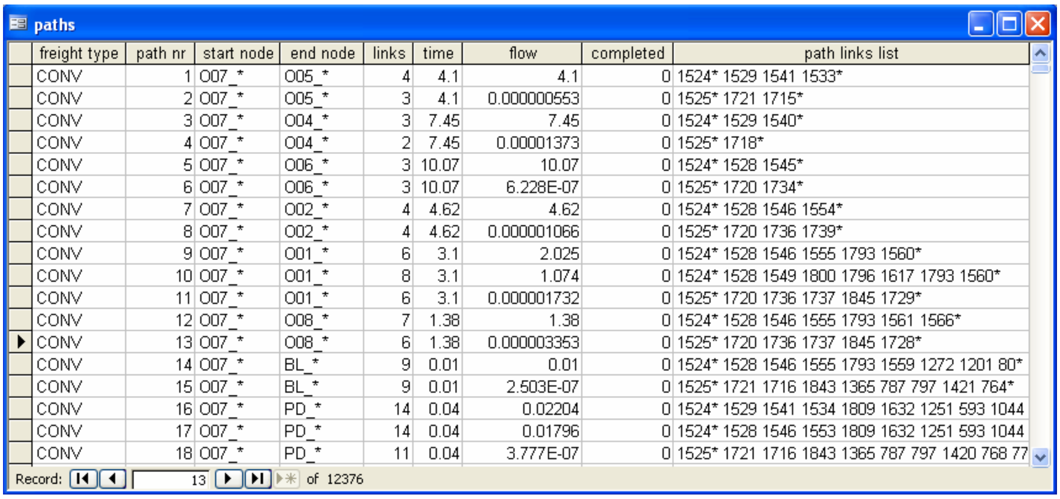
Where the information are internally structured as represented in the following pictures.

viewResultsComplete : Crosstab Query

nArco	nI	nF	modo	c_CONV	cost_eq	f_CONV	flux_eq	q_CONV	queue_eq	t_CONV	time_eq
19108	AG	AG	*s	0	0	0	0	0	0	0	0
19109	AL	AL	*s	0	0	0	0	0	0	0	0
19110	AN	AN	*s	6.239	6.239	49.5	49.5	0	0	2	2
19111	AO	AO	*s	6.239	6.239	0.5599	0.5599	0	0	2	2
19112	AP	AP	*s	0	0	0	0	0	0	0	0
19113	AQ	AQ	*s	0	0	0	0	0	0	0	0
19114	AR	AR	*s	0	0	0	0	0	0	0	0
19115	AT	AT	*s	0	0	0	0	0	0	0	0
19116	AV	AV	*s	0	0	0	0	0	0	0	0
19117	BA	BA	*s	0	0	0	0	0	0	0	0
19118	BG	BG	*s	6.239	6.239	11.03	11.03	0	0	2	2
19119	BI	BI	*s	0	0	0	0	0	0	0	0

Record: 6 of 1928

Figure 39: Results Database for Links


paths

freight type	path nr	start node	end node	links	time	flow	completed	path links list
CONV	1	O07_*	O05_*	4	4.1	4.1	0	1524* 1529 1541 1533*
CONV	2	O07_*	O05_*	3	4.1	0.000000553	0	1525* 1721 1715*
CONV	3	O07_*	O04_*	3	7.45	7.45	0	1524* 1529 1540*
CONV	4	O07_*	O04_*	2	7.45	0.00001373	0	1525* 1718*
CONV	5	O07_*	O06_*	3	10.07	10.07	0	1524* 1528 1545*
CONV	6	O07_*	O06_*	3	10.07	6.228E-07	0	1525* 1720 1734*
CONV	7	O07_*	O02_*	4	4.62	4.62	0	1524* 1528 1546 1554*
CONV	8	O07_*	O02_*	4	4.62	0.000001066	0	1525* 1720 1736 1739*
CONV	9	O07_*	O01_*	6	3.1	2.025	0	1524* 1528 1546 1555 1793 1560*
CONV	10	O07_*	O01_*	8	3.1	1.074	0	1524* 1528 1549 1800 1796 1617 1793 1560*
CONV	11	O07_*	O01_*	6	3.1	0.000001732	0	1525* 1720 1736 1737 1845 1729*
CONV	12	O07_*	O08_*	7	1.38	1.38	0	1524* 1528 1546 1555 1793 1561 1566*
CONV	13	O07_*	O08_*	6	1.38	0.000003353	0	1525* 1720 1736 1737 1845 1728*
CONV	14	O07_*	BL_*	9	0.01	0.01	0	1524* 1528 1546 1555 1793 1559 1272 1201 80*
CONV	15	O07_*	BL_*	9	0.01	2.503E-07	0	1525* 1721 1716 1843 1365 787 797 1421 764*
CONV	16	O07_*	PD_*	14	0.04	0.02204	0	1524* 1529 1541 1534 1809 1632 1251 593 1044
CONV	17	O07_*	PD_*	14	0.04	0.01796	0	1524* 1528 1546 1553 1809 1632 1251 593 1044
CONV	18	O07_*	PD_*	11	0.04	3.777E-07	0	1525* 1721 1716 1843 1365 787 797 1420 768 77

Record: 13 of 12376

Figure 40: Results Database for Origin and Destination

The MTCP guarantees the overview of any road network characteristics with the use of a GIS software. The files produced in fact, consist in information about: nodes, links and paths.

The user can:

- select itineraries for GIS output;
- create net shape files;
- create itineraries shape files;
- update database with shape files data;
- create shape files with output results.

2.2.4 Simulations and results

2.2.4.1 Road network performance

The concept and service developed and implemented in this case study was simulated both in Catalonia and Genoa sites. In particular, for the simulation of road network performance based on the Macro Transport Chain Planner (MTCP), the city of Genoa has been considered with feedback and evaluation from the Civil Protection.

As previously stated, to develop the case study, it was necessary to create a traffic model of the city of Genoa on which to perform the test.

The present chapter describes the activities developed in order to build up the transportation model of the city of Genoa and perform the simulations.

The following paragraphs describe in details the activities performed.

2.2.4.1.1 Zoning Design

In order to have a clear and spatial disaggregated idea of the origin and the destination of the trips, population, land uses, etc., the area of study has been divided into zones. This activity commonly defined “zoning design” represents the base of each activity related to the modelling of the transportation activities in the area.

The zoning system is used to aggregate all the information needed (individual households, premises, socio-economic data, etc.) for modeling purposes. The area of study is divided into small internal zones while the region external region to this one is normally divided into a number of bigger external zones. The main two dimensions of a zoning system are the number of the zones and their sizes, which are, of course, related. A right balance of them is fundamental for the success of the study.

The Genoa urban network developed in this project is related to 144 zones.

In the following pictures the 144 Traffic Analysis Zones (TAZ) of the zoning design are drawn (Figure 41).

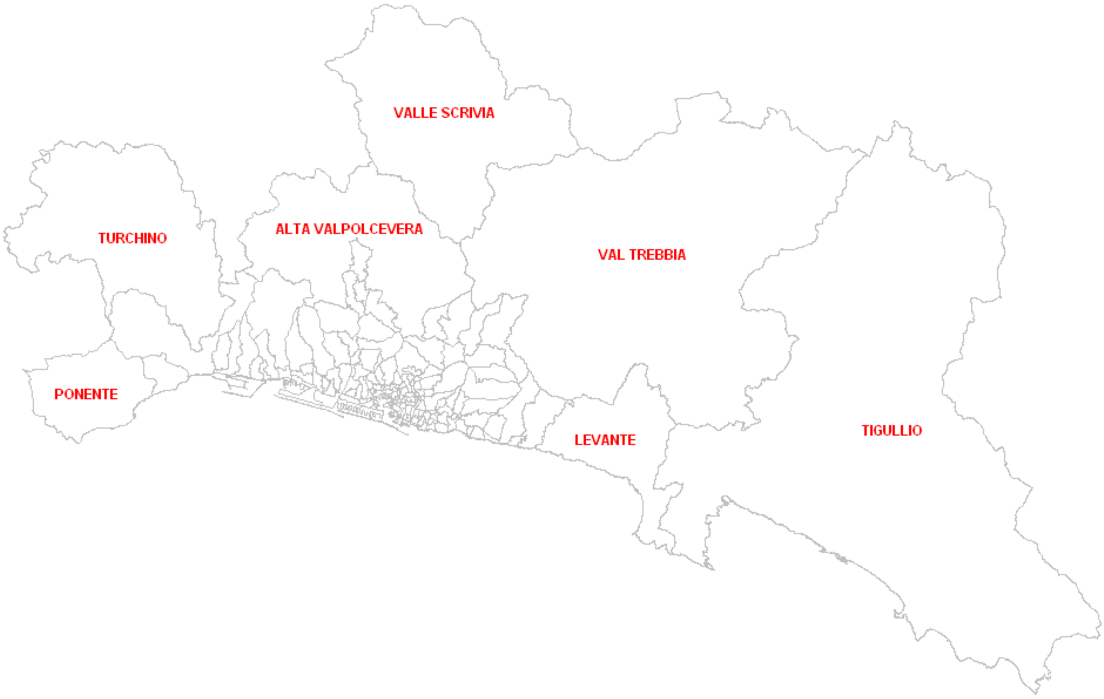


Figure 41: Traffic Analysis Zones (TAZ)

Every zone is represented in the model by a centroid closely placed geographically to the centre of the TAZ. Take into account that a centroid is the node where the characteristic of the TAZ in terms of Originates and Destinations are collapsed.

2.2.4.1.2 Design of the Road Network

The transportation network is deemed to represent the supply side of the modelling effort i.e. what the transport system offers to satisfy the movement needs of trip makers of the area of study. The description of a transport network in a computer model can be undertaken at different levels of details and requires the specification of its structure, its properties or attributes and the relationship between those properties and traffic flows.

The model of the Genoa urban network is based on 1462 nodes and 1550 links In the following picture the model (nodes and links) and the reference map of the road network of Genoa has been reported

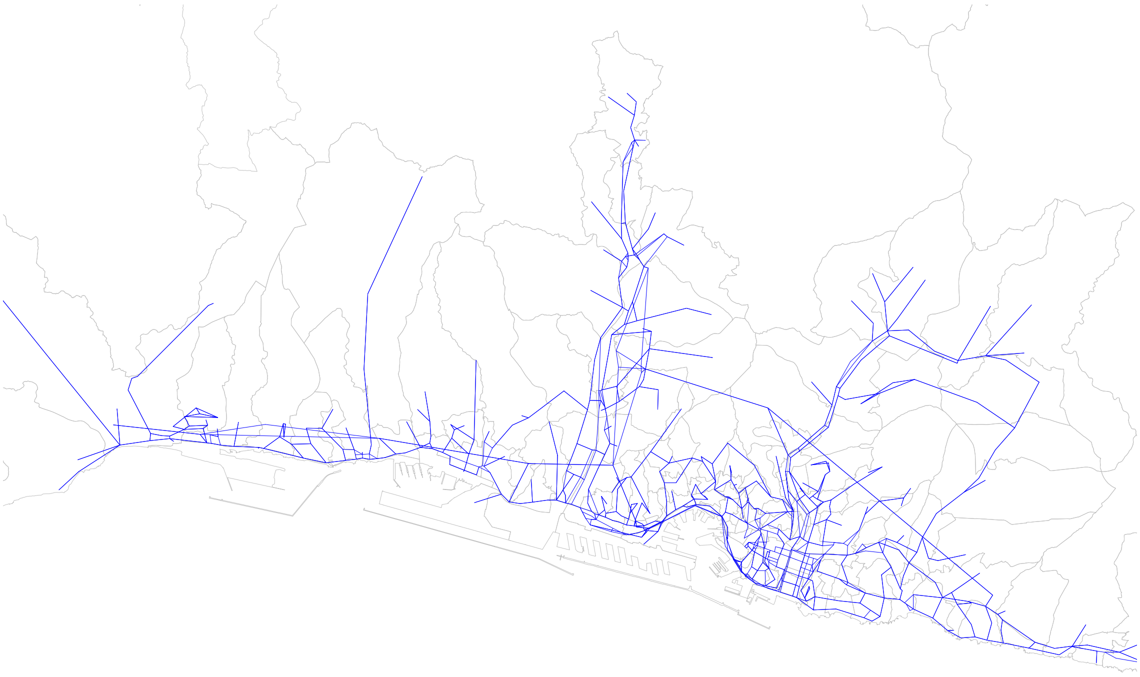


Figure 42: Road Network

The data derive from the node representation will be the followings:

- characteristics of the nodes (centroids and nodes);
- identification (ID) of each node (such us a short name for centroids and a number for the other nodes);
- coordinates of the nodes expressed in an appropriated projection.

The length has been measured with the GIS application. All the links are presently considered as bidirectional. The number of lanes has been derived from the given data. The capacity has been calculated on the basis of the number of lanes and the volume of traffic during the peak hour as reported in detail below. The commercial and project speed have been assumed as a fixed value accordingly with the traffic regulation.

2.2.4.1.3 Capacity

The link capacity has been calculated on the basis of the traffic flows data reported on hour basis.

The maximum hour flow for each considered link is been divided in lanes in order to obtain the maximum flow per lane per hour.

From this set of data, the values bigger than 2000 vehicles per hour or smaller than 1000 vehicles per hour have not been taken into account considering them as anomalies; the average of the remaining values is about 1600 vehicles per hour. This value has been assumed to the capacity per lane for each links within the second ring.

The capacity of the links represented rings and roads outside the fourth ring has been assumed to 2000 vehicles per hour.

2.2.4.1.4 Design of the OD Matrix

The development of the demand analysis has been performed on the basis of the following step:

- Development of a gravity model to generate the first OD matrix;
- Assignment of the OD matrix using the simulation model;
- Reconstruction of the OD matrix through comparing the observed traffic volumes with the simulated.

<u>The Gravity Model</u>

The gravity model has been generated from an analogy with Newton's gravitational law. It estimates trips for each cell in the OD matrix without directly using the observed trip pattern. The model has the following functional form:

$$OD_{ij} = \frac{\alpha \cdot P_i \cdot P_j}{d_{ij}^2} \qquad [1]$$

where Pi and Pj are the populations of the TAZs of origin and destination, dij is the distance between i and j and a is a proportional factor. This factor considers that the transportation model simulates the traffic of an hour.

In some case the Pj can be substituted with Wj that represents the likely number of workers of the zones:

$$OD_{ij} = \frac{\alpha \cdot P_i \cdot W_j}{d_{ij}^2} \qquad [2]$$

This second formula has been used for TAZs within the second ring, where the number of workers is higher than population.

The number of workers for these TAZs was not available; this number, for each TAZ, has been calculated proportionally to population in the same TAZ accordingly with the following formula:

$$W_j = \beta \cdot P_j \qquad [3]$$

The proportional factor b has been calculate in order to obtain the number of workers in the central zones equal to the sum of people who go from the second ring to the central zones.

<u>Assignment of the OD Matrix</u>

The OD defined with the gravity model has been assigned to the transportation network. This allowed to obtain traffic volumes in each link. These values have been compared with the observed traffic volumes for the most significant roads.

The traffic volumes are related on the peak hour and they are calculated on the basis of the collected values.

The peak hour, calculated on the basis of traffic in 290 road sections, represents the hour from 9 to 10 a.m. and from 5 to 6 p.m. Each two peak hours represent the 6% of the daily traffic flow.

Calibration of the OD Matrix

The used simulation software includes a specific tool (DAPROD) that allows to reconstruct and update an initial "design" OD matrix by evaluating the most reliable (maximum likelihood) OD matrix consistent with the flow measurements (counts) performed at selected location of the network. This tool is based on the entropy-maximising and information-minimising techniques that Willumsen (1978) has firstly used to derive a model to estimate matrices from traffic counts.

DAPROD updates the OD matrix, starting from this set of inputs:

- network routes, which link all the examined OD relationships (considering the $p_{ij,k}$ quota of the OD_{ij} relationship that is assigned to the j^{th} link);
- a set of measured flows on particular links (V_k values);
- a set of reference values (t_{ij}) for the examined OD_{ij} relationship (optional information).

DAPROD output are the T_{ij} values for the examined OD_{ij} relationships, which are congruent with the V_k measured flows (using information-minimising or entropy-maximising criteria).

The DAPROD procedure is based on an iteration process, and, at the n^{th} step, the $U_{k,n}$ flow values in the monitored links can be calculated. Generally, the $U_{k,n}$ flow values should be different from the V_k measured values; during the $n+1^{th}$ step, DAPROD will search for reducing these gaps (mathematic methodology based on the Lagrange Multipliers) to find the minimum-error solution.

The following picture shows the actions that this specific tool does.

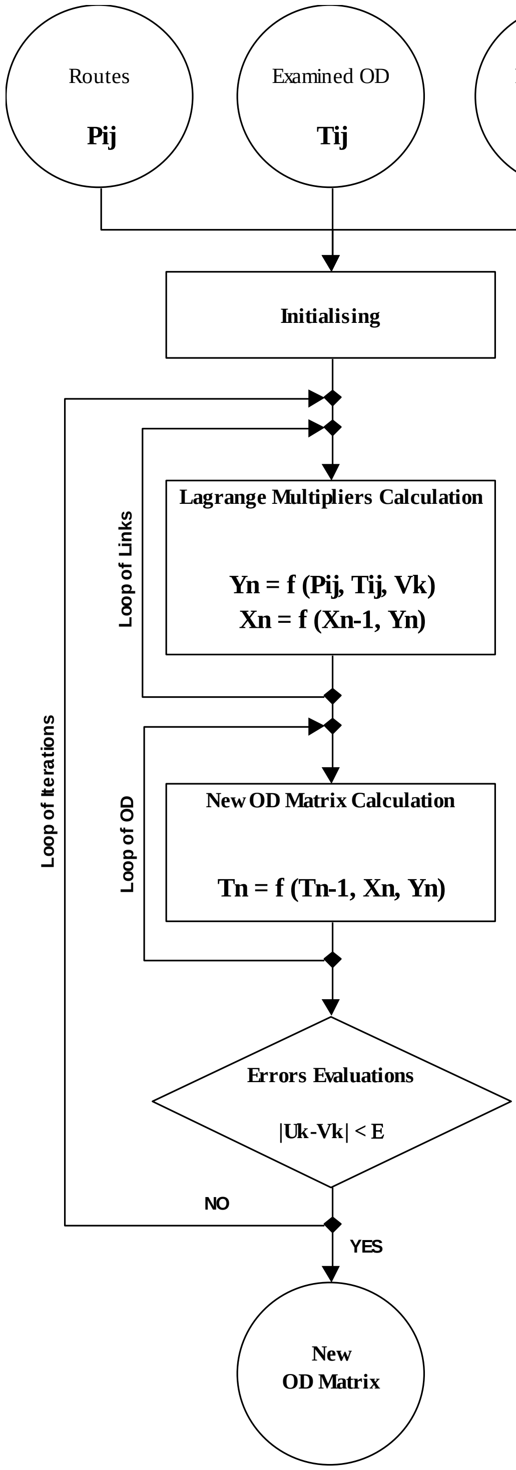


Figure 43: Road Network DAPROD Algorithm of Resolution

2.2.4.1.5 Simulations results

Through the DST interface the user can visualize the simulation results of three scenarios. The result is a road map concerning the traffic flows. The DST make easy to understand the condition thanks to the different colourings in order to emphasize the high or low concentration of vehicles.

<u>Scenario 0</u>

Invoking the Scenario 0 the user obtains the standard traffic flows.

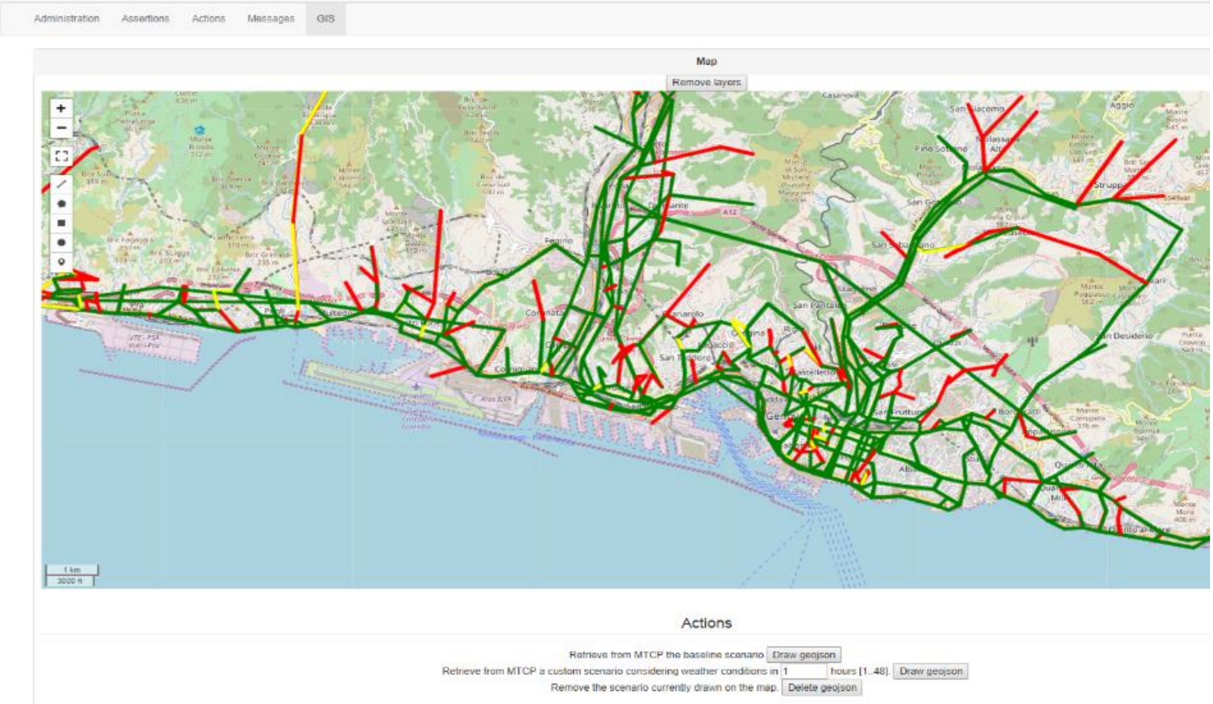


Figure 44: Scenario 0 results

<u>Scenario 1</u>

The results of the invoking the Scenario 1, it is possible obtain the forecast traffic condition affected by the weather events. The user can choose to apply from 1 to 48 hours Road Condition and circulation impact as provided by UPC-CRAHI.

<u>Scenario 2</u>

Through the DST interface the user can associate a different capacity to one or several roads of the maps. In this condition the result of the Scenario 2 is a road map condition with the traffic flows diverted/rerouted due to user choices (i.e. road closures).

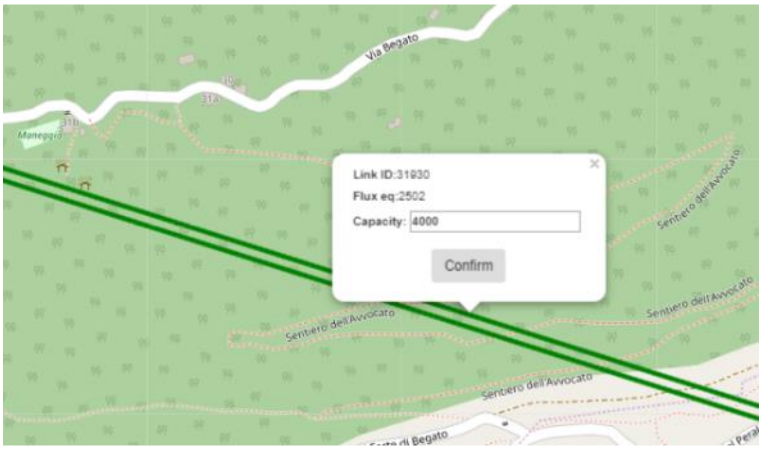


Figure 45: User can change the flow parameters

2.2.5 User feedback

The evaluation from the stakeholders of the case study showed that the concept and functionalities of the developed tool for forecasting the impact of high-impact precipitation events on the road network is promising and perceived as useful.

In the following, a summary is reported of the evaluation of the stakeholders during the design and implementation of developed tool.

The user feedback was collected through a series of meetings during 2018-2019:

- April 2018: UPC-CRAHI and CEDAC director board. Preparatory meeting to involve CEDAC associates in the project.
- 10/05/2018: Meeting between RINA-C, UPC-CRAHI, CEDAC associate and CEDAC director board in Barcelona (Spain)
- May-October 2018: UPC-CRAHI and CEDAC associate. Several follow-up meetings in Barcelona (Spain).
- 31/10/2018: RINA-C, Italian retailer company group in food market at Genova
- 24/10/2018 – 05/02/2019 – 15/03/2019: Different meetings between RINA-C and Protezione Civile di Genova at Comune di Genova

The tool for testing purpose has been configured by implementing the Catalonia and Genoa road network based on the flood / snow impact forecasts generated in real time during the implementation period (winter 2018-2019). During the period and different meetings with stakeholders, fine tuning of the interfaces and functionalities have been performed. The developed tools were initially not expected/intended to be included in any of the A4* tools. Because of the interest of the corresponding Civil Protection authority, a posterior inclusion have been considered.

The solutions have been designed to be accessed through a web browser, and also serve the products of road and circulation conditions through an API (or, alternatively, via FTP for registered users). From hardware/software point of view the solution did not present particular criticalities. Currently, the solution has been implemented in a server using the weather and hazard forecasts served by the MH-EWS.

Preliminary feedback has been collected in the development phase by in person meeting, and a general report on the performance of the tools. In general, the comments about the web-based platform to forecast the road and circulation conditions during winter 2018-2019 are positive and were developed according to the requirements of the user. However, one factor limiting the interest of the provided reports is the lack of significant events during the studied period.

In terms of performance feedback and improvement, the response time is in line with standard expectation for light web pages. The complexity of the road network impact on the time performance although is totally in line with operational use and expected performance in planning and preparedness phases.

The significant impacts of weather events on the performance of the road network justifies the interest of this case study. The tools developed in this task, demonstrate that the concept is operationally feasible and potentially replicable to other sectors.

The solutions enable relevant applications both for stakeholders and municipalities such as:

- Improved management of stocks by including impact forecast information in the operation of a logistics platform.
- Scenarios comparative analyses in urban, regional, national and international context

For a long term prospective, the solutions may be tailored in order to increase economic benefit of the transportation entities by reducing the overall operating costs, develop and maintain a higher standard in customer service and attain unsurpassed efficiency (i.e. better shipping options, reduced operational costs, predictive operations, etc.).

2.2.6 Identification of Business Case

This section aims to examine the commercial relevance of the products and services conceived for the current case study, in order to assess the potential for commercial exploitation and the capability of ANYWHERE concept to be sustainable.

Regarding the capability to enable self-response of logistic platforms of food distribution companies, there are currently two web-based services:

- A web service to estimate weather impact on roads in terms of snow accumulation and implications on circulation;
- A web service tool exploiting the products of the ANYWHERE MH-EWS (by road conditions forecasting module) calculating the impact on road network capacity in terms of traffic and other relevant logistics-related information (costs, routes, queues, velocity, etc.)

Based on interviews and meeting with different stakeholders dealing with transportation tasks (i.e. CEDAC, Genoa municipality), the solutions have been conceived to fulfil specific needs, framing in this way the value proposition of the service, below reported:

- Early (time anticipation) and reliable (exactly where) of weather information (proposition of MH-EWS)
- Impact on the roads:
  - weather-based unavailability – light/heavy snow on specific roads
  - traffic-based unavailability – identification of vehicles concentration in specific roads
- Early planning customized for the stakeholder, following their priorities (e.g. type of goods):
  - To minimize costs and losses;
  - Possibility to find alternative logistics configurations (i.e. type of vehicles, path, etc.)
- Trusted information because used as source from trusted entities (i.e. Civil Protection)
- Replicability to stakeholders with different perspective and pursuing different objectives: Civil Protection / emergency forces (driver: in terms of safety and society protection) and CEDAC / logistics and transportation stakeholders (driver: ensure business continuity and minimize costs in disruptive events on roads)

Such value proposition is based on confirmed drivers that justify the tools/products development compared to the expected benefits for the stakeholders involved. But to ensure the robustness of such proposition is necessary to identify which is the innovation content in relation to the benefit for customers/users, which paves the way for potential commercial exploitation of the solutions.

In the following a table representing the suitability of the considered solutions to these aspects:

Table 11. Identification of Value Proposition, target users and form for exploitation

Innovation content	Translating weather observations and forecasts to the impact on road and traffic conditions customized to the needs of the end-user (e.g. food distribution logistics platforms)
Potential customer/user	Logistics platforms in charge of coordinating the distribution of fresh food or perishable goods. In general, any institution with activities affected by road performance and traffic conditions.
Benefit to customer/user	Improved decision making incorporating the effect of weather conditions (particularly snow) on the road and traffic conditions
Relation with ANYWHERE MH-EWS	The module for forecasting road and circulation conditions on the road network (UPC-CRAHI) uses Numerical Weather Prediction products served by the MH-EWS, and serves results to the road network performance module (RINA).
Potential form for exploitation	Commercial exploitation (SaaS), consultancy service;

2.3 Increasing self-protection in camping located in flood prone areas

Catalonia is a high touristic area with a number of camping sites located in flood prone areas having suffered several flooding events in the past. Currently there are more than 350 camping sites in Catalonia with capacity for more than 273.000 people, and almost half of them are in high risk of flooding (see Figure 46).
Moreover, according to Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks (23 October 2007), those areas identified for which significant flood risks exist or might be considered likely to occur shall implement flood risk management plans. Those risk management plans in many cases might involve flood Early Warning Systems. The flood EWS will be useful to trigger the appropriate actions from the plan in the case that a potential hazard is foreseen. In this context, the objective of this task is to **build a flood self-protection service for camping areas using the flood-specific models and tools (T2.2 of WP2) provided through the services and interfaces of the MH-EWS (WP3)**. This service should be developed in close collaboration with the Civil Protection of Catalonia and the Catalan Water Agency while keeping a sustained interaction with the camping sites to take their needs and feedback into account.

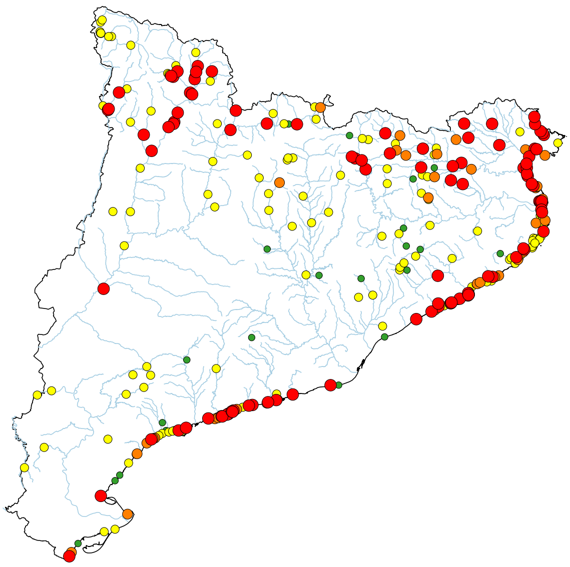


Figure 46: Classification of campsites in Catalonia in terms of flood risk. Red – High risk (45%), Orange – Medium risk (19%) Yellow – Low risk (20%), Green – Without risk (16%).

2.3.1 Problem definition

The flood EWS developed in this task needs to fulfill administration requirements and recommendations. Any campsite in Catalonia, as other activities, needs to implement its own self-protection plan which includes a wide variety of potential threats that may appear. This plan has to be approved by Civil Protection in order to be allowed to

continue with the activity. Regarding the flooding risk, which is the main issue for campsites located in flood-prone areas, Civil Protection relies on the Water Agency criteria for the approval (or not) of the self-protection plan. In many cases, an Early Warning System is being required for such campsites.
The transposition of the European Directive into national and regional laws is being deployed progressively and, so far, no specific legal requirements for EWS are published. The Catalan Water Agency issued a list of basic criteria that such systems should comply with. These criteria are expected to be modified and adapted to each particular case during the implementation across the country. Nevertheless, it is a good starting point for the design of a prototype that eventually will be validated as an EWS. Among others, these basic criteria include the use of:

- warnings based on weather radar data
- rainfall nowcasting up to 2h
- official warnings issued by the Meteorological Service of Catalonia
- sensors (river gauges and/or rain gauges) located near the activity

Besides administration requirements, the tool should be adapted to campsite manager's needs, for example:

- easy access
- a user-friendly interface
- self-protection actions associated to warnings
- customization for each campsite

This case study is meant to be a unique opportunity to be in close contact with both administration and potential users during development, paving the way for future implementations of the system.

2.3.2 Development and implementation

A web-based tool called A4CAMPSITE has been developed. It is an Early Warning System for floods that integrates in a single place all the flood-related information: real time sensor data, official warnings and self-protection actions.

2.3.2.1 A4CAMPSITE Description

The A4CAMPSITE prototype is intended for managers of campsites or other establishments in a flooding area, and allows tracking of potentially dangerous rain episodes.

The tool is customized for each campsite, each manager can access it through a web page with a username and password. Each campsite has associated sensors and products, as well as its own plan of self-protection.

2.3.2.1.1 Data display view

The main screen of the tool is the Map section and allows to get a quick overview of the situation and have access to relevant information at all times.

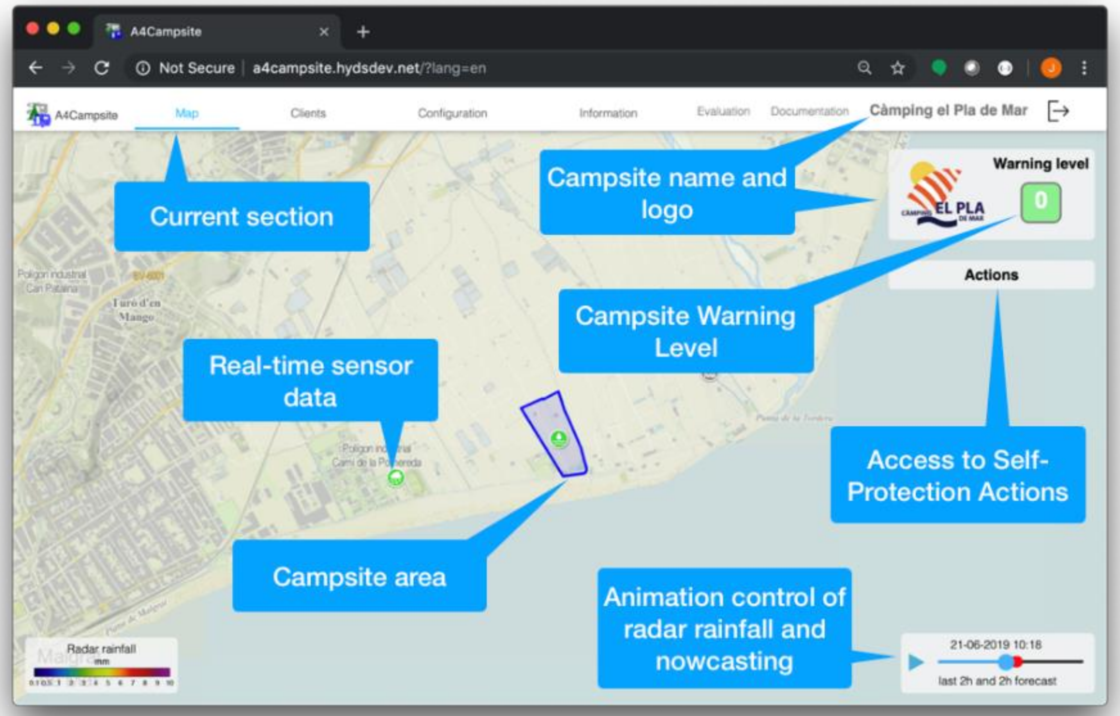


Figure 47: Diagram of the A4CAMPSITE main screen

The most important elements on this screen are:

- Warning Level, which summarizes the current situation in the campsite (in terms of the risk of flooding),
- An animation of the radar rainfall in the last two hours and the forecast in the next two hours,
- An action button that brings to the list of tasks to carry out in case of warning.

2.3.2.1.2 Monitoring levels of warning

The Warning Level of the camping site can take three possible states, in accordance with the states of the self-protection plans:

- Level 0: Without risk
- Level 1: Warning
- Level 2: Emergency

The A4CAMPSITE prototype obtains real-time data from sensors, ANYWHERE products and official notices. Each of these products has at all times assigned a warning level (0, 1 or 2) based on previously configured thresholds. Then the level of the campsite warning is defined as the maximum levels of warning for all products. The level of the campsite warning is continuously updated, since it is recalculated every time new data is available.

In the following example, it is seen that in the rivergauge of Sant Celoni the threshold of level 1 is exceeded, and in the list of products it is shown marked in orange. As the rest of the products come in green (level 0) the maximum of all of them is 1 and the campsite is at warning level 1.

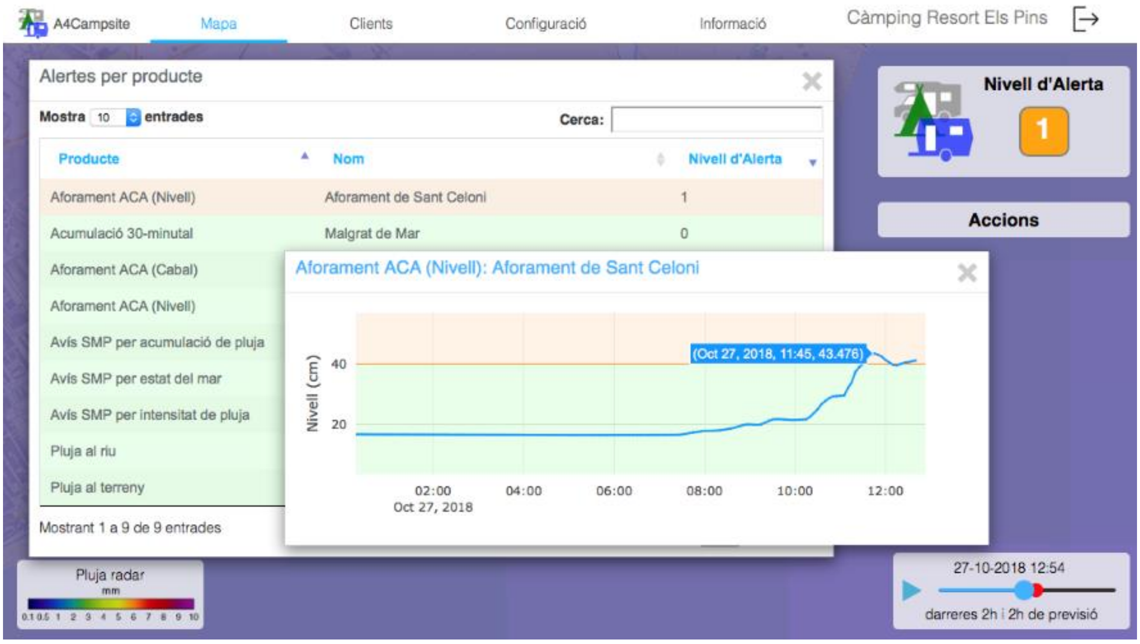


Figure 48: Screenshot showing the activation of a warning level by a river gauge

2.3.2.1.3 Support in a warning situation

The tool automatically sends to the camp managers a text message or email (depending on the configuration) whenever a warning level is activated. In this way the manager can consult the application at that time to evaluate the situation and does not need to be watching the tool all the time.

Using the Actions button, one can access the list of tasks associated with the warning level. This list must be previously defined through the configuration tab. All actions indicated in the self-protection plan as well as other tasks that should be remembered should be included. You can see an example in the image below.

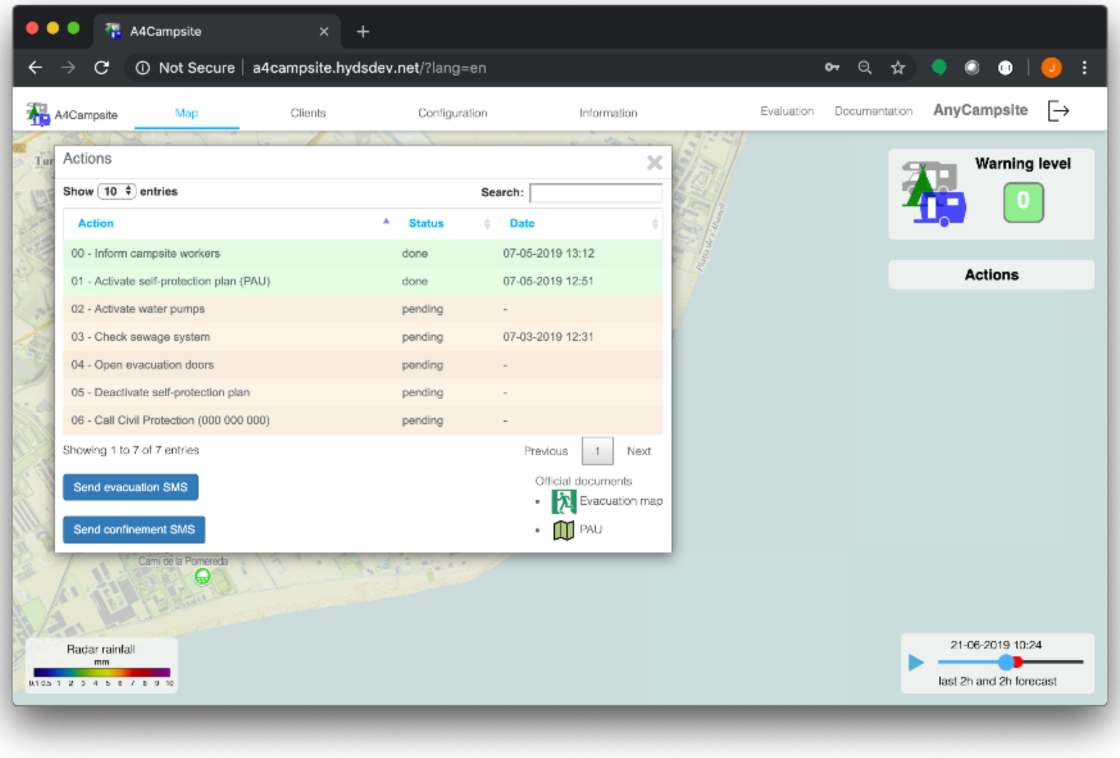


Figure 49: A4CAMPSITE self-protection actions window

Further, at the same window there are other elements that can be useful:

- • Change of action status: To mark actions that have already been done, you can click on the row of an action and it will go from “Pending” to “Done” (and the background will pass from orange to green). In addition, the date and time in which it has been marked will be indicated. After an important episode, you can reset the status of the actions through the configuration.
- • Official documents: At the down-right corner, we have two links to official documents, one on the evacuation map and another to the self-protection plan (PAU). In this way they are easily accessible from the application if they have to be consulted.
- • Sending text messages: At the down-left corner there are two buttons for sending messages to the campsite customers. There are two predefined messages, one for evacuation and another for confinement. Camping customers are defined on the Customers tab.

2.3.2.1.4 Configuration

The Configuration section controls the different parts of the tool that can be modified. There is a side menu that allows to navigate through the different sections.

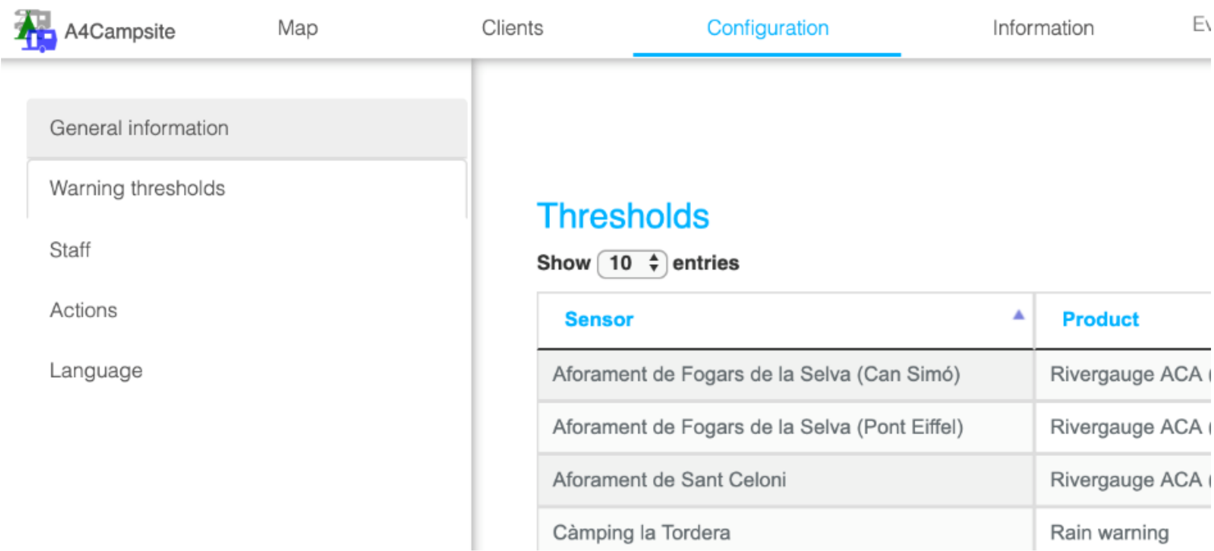


Figure 50: Side menu of the Configuration section

- In “General Information” there are different data from the camping of the account in operation.
- In “Warning Thresholds” one can see and change the different thresholds that activate the levels 1 and 2 for each product.
- In “Staff” one can edit the list of employees who receive emails and automatic text messages.
- In “Actions” one can edit the list of actions and reset them all to pending.
- In “Language” one can choose the language of the application between Catalan, Spanish and English.

2.3.2.2 A4CAMPSITE data sources

The products used to calculate warnings on each camping can be retrieved from three different sources: sensors, ANYWHERE products and official warnings.

2.3.2.2.1 Sensors

The tool includes two types of sensors:

- Rain gauges (Meteorological Service of Catalonia): From these rain gauges the accumulated rain is obtained in half-hour periods. In addition, the tool also calculates the accumulation in 24 hours in real time.
- River gauges (Catalan Water Agency): River gauges can register river discharge or river level at a particular point.

The A4CAMPSITE prototype is flexible enough to also include sensor data belonging to campsites, if any.

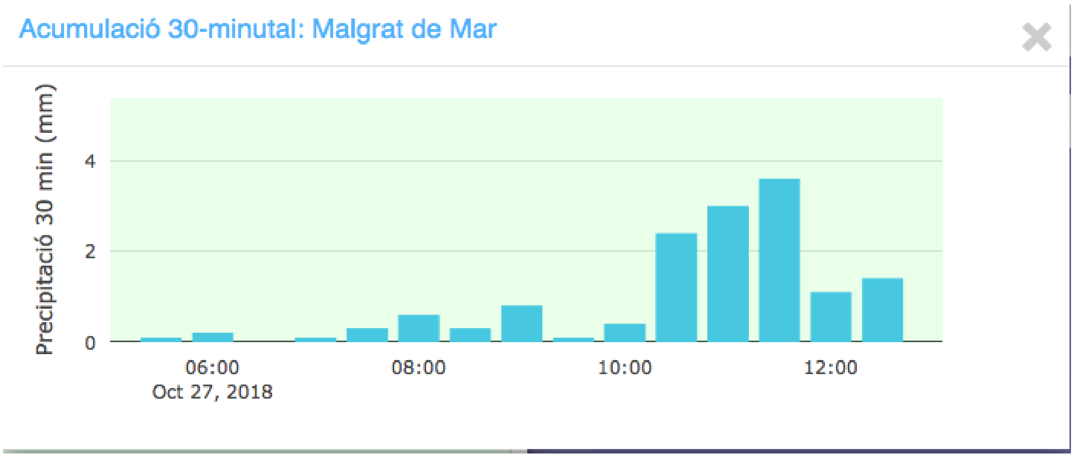


Figure 51: Graphic of the evolution of precipitation registered with a raingauge.

2.3.2.2.2 Products ANYWHERE

Two products from the MH-EWS (WP3) developed by UPC are available. These products are derived from weather radar precipitation estimates.

- Rainfall warnings: This product shows the return period of rain accumulated in half an hour at a point. It uses the accumulation of rainfall obtained with meteorological radar and combines it with the IDF curves (Intensity - Duration - Frequency) of each point in the territory. In addition, the forecast of the return period for two hours is also included.
- River warnings: This product shows the return period of rain accumulated recently in the contributory basin of a river point. So out of the rivers, this product does not make sense. It also uses the accumulation of rain obtained with meteorological radar and combines it with the IDF curves of each point (of river in this case). There is also the forecast of the return period at two hours.

2.3.2.2.3 Official warnings

The Meteorological Service of Catalonia (SMC) issues regional warnings following the prediction of several Meteorological Hazardous Situations (SMP).

A human team of expert predictors, based on forecasts of numerical models of meteorological forecasting and data observed through various instruments, interprets the situation and issue warnings for different meteorological phenomena based on their "rarity" and potential impact.

According to the probability of the phenomenon and its intensity, 6 levels of danger are defined from a contingency table (see image) summarized in 6 alert levels, coded in a 3-way traffic light scale.

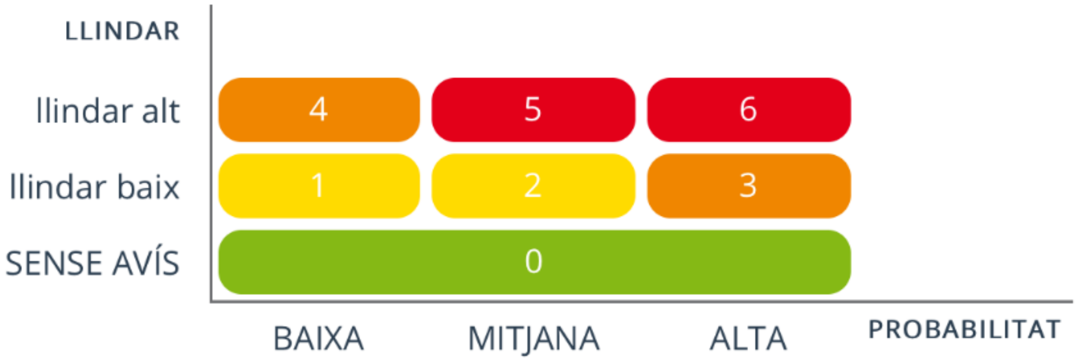


Figure 52: SMC Contingency table of alert level combining the threshold exceeded (Y axis) and the probability of exceedance (X axis).

The A4CAMPSITE prototype includes up to three types of warnings issued by the SMC:

- SMP Rain Intensity Warnings
- SMP Accumulation of Rain Warnings
- SMP State of the Sea Warnings

2.3.3 Simulations and results

This case study has been carried out with the participation of 14 campsites belonging to the Association of La Tordera river mouth Campsites ("Associació de Càmpings del Delta de La Tordera"). La Tordera river is located in Catalonia, about 50 km away from Barcelona. The lower reach of the river indicates the limit between two municipalities, Blanes and Malgrat de Mar. Campsites are located on both sides of the river and (mostly near the beach) and within the flooding area.

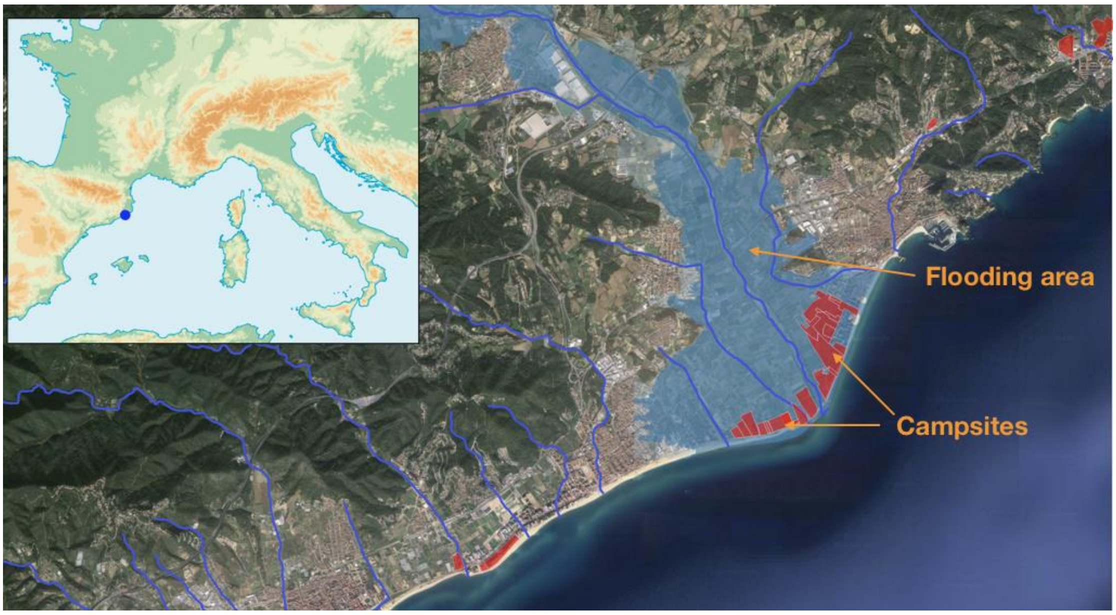


Figure 53: Situation of La Tordera river mouth. River courses in blue, flooding area in transparent blue, campsites in red. Campsites in flooding area are the case study target.

2.3.3.1 Test phase

The test phase started on the 20th July 2018 when access credentials were delivered to the managers of the following campsites:

- Càmping Bellaterra (Blanes)
- Càmping La Tordera – Les Nacions (Malgrat de Mar)
- Càmping Solmar (Malgrat de Mar)
- Càmping Roca (Blanes)
- Càmping Resort Els Pins (Malgrat de Mar)
- Càmping La Masia (Blanes)
- Càmping La Conca (Malgrat de Mar)
- Càmping El Pla de Mar (Malgrat de Mar)
- Càmping El Pinar (Blanes)
- Càmping del Mar (Malgrat de Mar)
- Càmping Celmar (Malgrat de Mar)
- Càmping Blaumar (Malgrat de Mar)
- Càmping Blanc (Blanes)
- Càmping Marysol (Malgrat de Mar)

The objective of the test phase was to verify the applicability of the tool and gather possible improvements based on the user experience. The thresholds determining the warning level in each product and sensor were provisional and modifiable along the phase. In fact, in order to test the complete flow of data (measurement – warning calculation – SMS/mail delivery) very low thresholds were set on purpose.

Despite no flooding incidents happened during the test phase some remarkable events took place, allowing to verify that the complete system worked successfully. On 15th October 2018, the storm Leslie passed over Catalonia, accumulating more than 100 mm in 12 hours in many places and more than 200 mm in some points. No personal damages were registered, but there were road closures and flooding basements. The campsite area in La Tordera river mouth was not specially hit by the storm, but La Tordera basin accumulated between 80 and 150 mm and the level of the river rose very fast.

The lower reach of La Tordera river is usually dry in summer due to the overexploitation of the aquifer (population is multiplied by 2 or 3 in surrounding villages, irrigation needs increase…). In autumn, the river level rises again but in 2018 it happened very fast (about 2 days).

Figure 54: On the top a picture of the lower reach of la Tordera river, taken on July 2018 from a bridge connecting Blanes and Malgrat de Mar. At the bottom a picture taken from the same point to the same area on the 15th October 2018, after Leslie storm episode.

A4CAMPSITE showed it in real time, several thresholds were exceeded, and the system sent the corresponding warnings successfully.

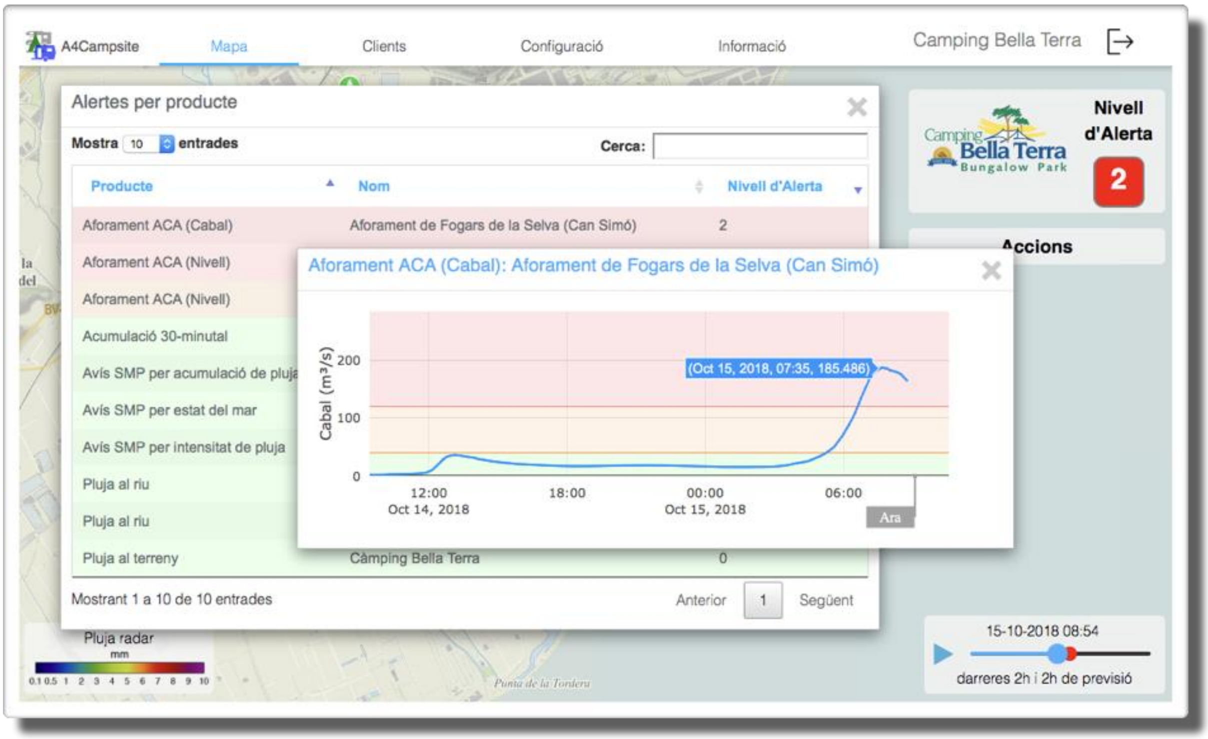


Figure 55: River discharge increase showed in A4CAMPSITE in the rivergauge of Fogars de la Selva during the Leslie storm episode.

In this and other events warnings have been sent and several campsites took preventing and monitoring actions.

2.3.3.2 New river level sensors

On 20 March 2019, new river level sensors were installed, provided by the company RAB Consultants (part of the ANYWHERE consortium), to complement those already existing in the Water Agency network. These sensors send the data to a receiving device located in a nearby installation. These devices upload data to the internet and make them available for the A4CAMPSITE.

The locations of the new sensors have been chosen according to criteria of proximity to the activity (ACA already has sensors in other sections) and river courses without instrumentation.

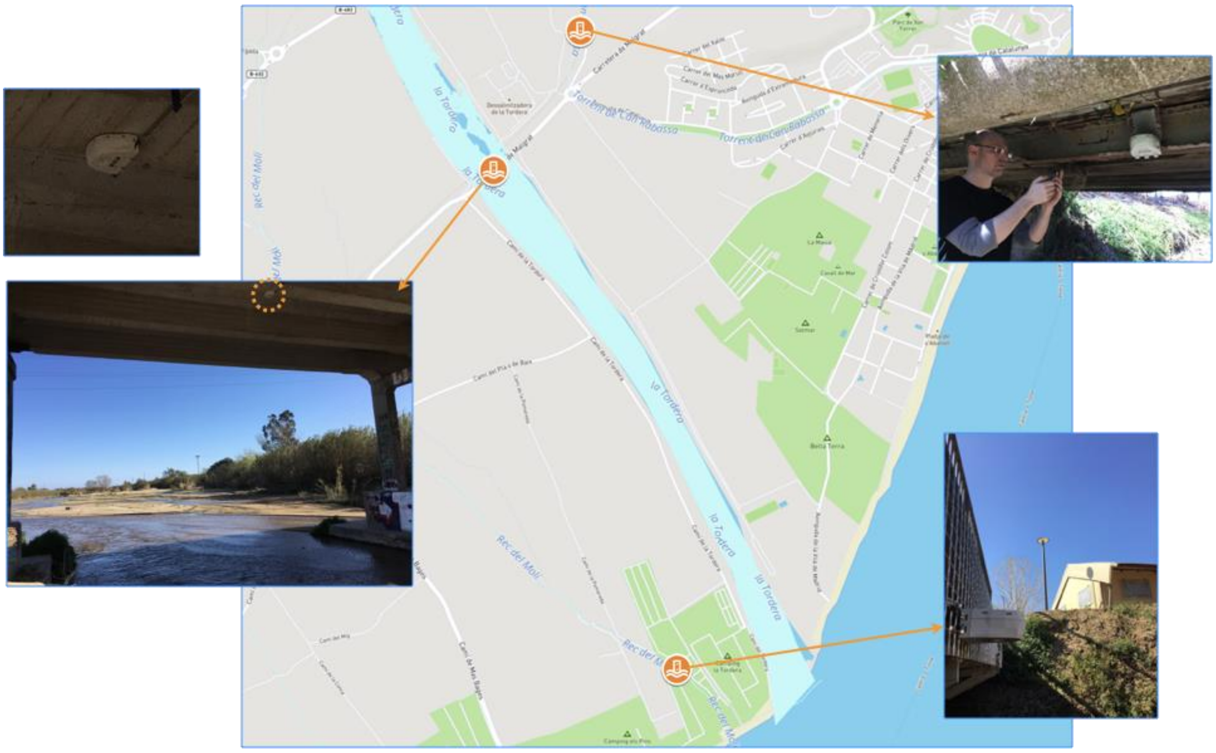


Figure 56: Locations of the RAB sensors installed and pictures.

On 22 March, the data of these new sensors had already been included in the A4CAMPSITE.

2.3.4 User feedback

Informal feedback has been received all along the test phase. In order to collect it formally and systematically, an online questionnaire has been included in the tool itself. In the questionnaire, users can provide up to 4 types of feedback:

- General evaluation of the tool
- Performance after an episode
- Possible bugs
- Suggestions for improvements

The tool is accessible through a web page: a4campsite.hydsdev.net and user/password for each campsite. A simulated user has been included for demonstration purposes: [User: campsite / Password:campsite].

Flash floods products from the MH-EWS are integrated in the tool, namely "rain warnings" and "river warnings".

The tool was configured to allow users to adjust the thresholds for each product or sensors, include people receiving automatic messages. During the test phase both possibilities have been used several times. No flooding events occurred, but in rainfall episodes warnings were delivered successfully and on time.

Up to now the general evaluations of the tool are positive, they found it easy to use and to understand. There was no previous similar tool in any of the campsite, so it clearly outperforms previous “human” procedures to anticipate and manage flood risk.

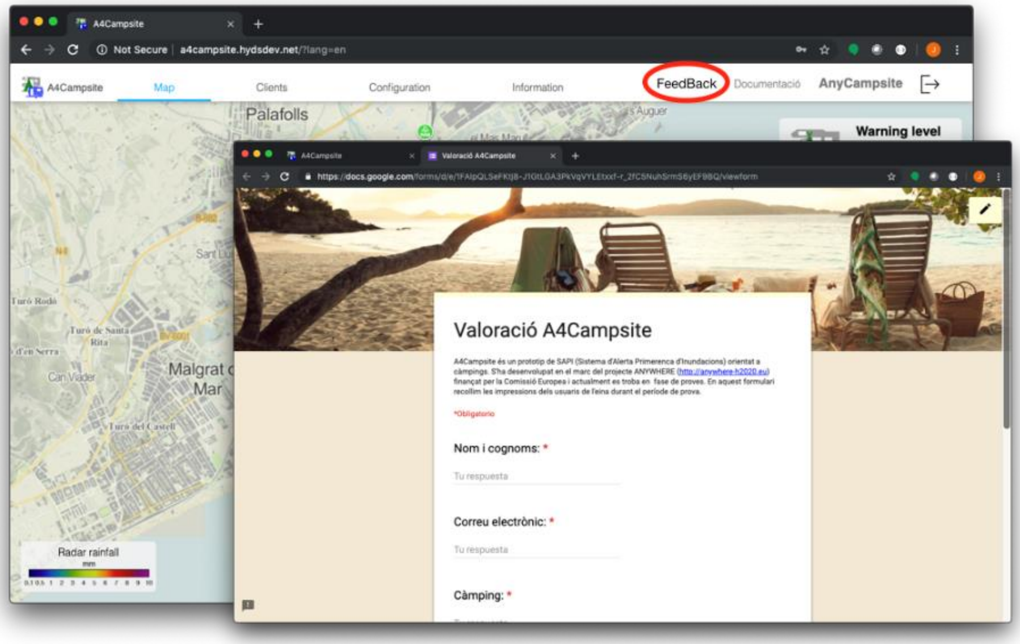


Figure 57: Link to online questionnaire in A4CAMPSITE and screenshot of it.

Very little feedback has been collected after the event: we only had some opportunities to check that all information loop (measurement – warning calculation – SMS/mail) worked flawlessly. That is why the tool and the feedback questionnaire will be available some more months to capture some more events.

No bugs have been reported, but some interesting suggestions arose, such as: the inclusion of a historical record of actions taken (for reporting purposes) or the distinction between users of full capacity and others with restricted access. Those will be taken into account in future versions of the tool.

In long term prospective, users involved in the test phase are interested in contracting the tool after the project end. Besides that, there are other Campsite Association that already showed interest in such a tool.

2.3.5 Identification of Business Case

In order to examine the commercial relevance of the current case study, a clear identification of the products and services developed and implemented is necessary as first step to assess the unique selling proposition.

Regarding the capability to increase self-protection in camping located in flood prone areas, there is currently:

- An Early Warning System to enhance flood self-protection in campsites and other activities at risk through official warnings as well as self-protection plans and interactive checklists, proposed as a Software As A Service (SaaS), which can include flood-information provided by sensor data and interfaced to MH-EWS products.

Based on interviews and meeting with various stakeholders dealing with camping activities (i.e. 14 camping sites in La Tordera river), the solution is conceived to fulfil specific needs, framing in this way the value proposition of the service. Specifically:

- Enhanced integration capabilities: Most campsites do not have any tool to manage flood risk. There are sensors in the market with its own software and warning levels, but no other resources integrated. To our knowledge there is no tool in the market that integrates sensors in place, radar data and warning levels together with official warnings and self-protection plans.
- Easy access and usability of technology advancement: A4CAMPSITE uses advanced radar-based products in terms of return period (obtained from the MH-EWS) which are not available in the market.
- Compliance to public acts: A4CAMPSITE is taking benefit from the recent move of the administration to make available official warnings in real-time in computer-friendly access and format.
- Flexibility to different stakeholders / replicability: A4CAMPSITE is intended for campsite managers but with no significant development can be adapted to other activities in flooding areas: industries, outdoor events, municipal activities.
- Scalability: A4CAMPSITE can be implemented in other European places than Catalonia, prior evaluation of local specificities in terms of sensors provision and official warning procedures.

After the identification of the value proposition, is necessary to properly link the innovation content of products and services to the benefit for customers/users, justifying the potential commercial exploitation of the solutions.
In the following a table representing the suitability of the considered solutions to these aspects:

Table 12. Identification of Value Proposition, target users and form for exploitation

Innovation content	The platform integrates Anywhere MH-EWS products, local products (local implementations of MH-EWS products, local sensors: rain gauges, river gauges, official warnings, etc.) and specific site self-protection information (self-protection plans, evacuation maps, etc.)
Potential customer/user	Camping sites, Industries, Municipalities, Other activities that take place in areas at flood risk.
Benefit to customer/user	Risk mitigation (for municipalities and campsite entities), achieve direct information from official warning (campsite users), achieve wide number of potential new users (sensor providers)
Relation with ANYWHERE MH-EWS	The web service is directly interfaced with the MH-EWS
Potential form for exploitation	Commercial exploitation (SaaS)

2.4 Increasing self-awareness and self-protection in front of flooding risk in schools

During the 2011 Flash Flood in Genova, 4 out of 6 casualties induced by W&C emergencies were related to schools. The Municipality of Genoa since then started a program to guarantee the safety of children in all the schools in its territory. In this task the safety of children in school was extended by defining and developing a system that is able to inform their parents through an appropriate service about the impact of the weather conditions in the schools all over the Municipality of Genoa city.

The tool has been built based on a participative approach. The first months of development have been aimed at building-up a team composed by representatives of parents, teachers, head teachers, civil protection operators and ANYWHERE partners. These local stakeholders group defined the best way, both procedural and technological, to inform the parents about the specific situation of their children's school in case of an emergency related to flood. This information helps them in better reacting during this kind of events.

Figure 58: A snapshot of the full scale exercises done in the Municipality of Genoa in 2018 and were the service developed in ANYWHERE has been tested.

Within ANYWHERE, the tool A4Schools has been developed. It is based on TELEGRAM, to improve and speed-up the communications between schools, emergency managers and parents.

A4Schools standardizes and improves the communication protocols between schools and emergency managers and it is able to provide customized information to the parents about the impact of the weather conditions on the schools all over the Municipality of Genoa city by suggesting them the safer behavior to protect their children and themselves (e.g., which are the schools affected by the event, the protocol followed by the schools to protect the children and that the children are safely cared by the school's people, information about safe roads in the affected area depending on the observed situation).

On 16 May 2018, the Municipality of Genoa organized a full-scale exercise with the aim of testing the capabilities of schools in reacting to a flood alarm message and in following the operational protocols and the internal emergency plans.

A4Schools has been tested during this event and showed the capabilities of providing to the parents customized information about the situation of their children at school and, at the same time, provided the decision makers with a complete picture of the safety level in each school.

2.4.1 Problem definition

The main objective of this activity is to develop a tool to communicate with schools and families in order to protect pupils and parents in emergency situations.

This section reports the main outcomes of the internal working group discussions for the tool definition as well as the structure of the service and the end-user guide provided for subscribing and using the service.

For what concerns the internal working group activity, the fist idea was to create an app where parents had to log in to receive information from their children’s school. This approach however does not guarantee to reach a large audience and have a sufficient impact on the possible users.

As a first step, the development team decided that this app has to be used not only during the emergency, but also be always active to inform parents of safety procedures, flood risk areas and school emergency plans. However there has been different points of view regarding the daily use and not a common consensus has been reached.

According to some participants to the stakeholders’ group the app had to be checked every day, on the other hand others thought that it would be too irritating and would hide important information.

At the end, the working group decided to focus on the development of the system for the use during emergencies. For this reason, it has been decided not to develop a specific app that may suffer of major problems related to:

1. the maintenance of the service
2. the capability of not working for months (even one year) maintaining the full capability of providing information and collect feedback in case of need.
3. the use of an app whose technological services cannot prove to be reliable and may need a long-term testing activity.

The working group then resorted to the use of a “bot” developed within the TELEGRAM App for several reason, but mainly because is a communication application used by millions of people, it is well maintained and updated, free of charge for the users and open for the services developers. For these reasons the Municipality of Genoa can rely on a powerful IT system and concentrate in developing the services request by the local end-users.

2.4.2 Development and implementation

The whole process followed these steps:

1. **Identification** of pilot **schools**.
2. **Identification** of a group of **local stakeholders** (head teachers, teachers and parents). The aim of the team of local stakeholders has been to help ANYWHERE partners in defining the requirements and expectation of the APP.
3. **Collection** of **requirements** and **suggestions** integrated with communication tools, already developed and used by the Municipality of Genoa in the phases of prevention preparedness and response.
4. **Design**, **development** and **test** of the service

Following this development process, procedures that integrate the AEU system output with A4Schools has been defined.

In the following is reported the agreed workflow of the service.

During a flood event, A4EU is providing to the Civil Protection operators a map of possible flooded areas in the next 30 minutes / 1 hour. If the schools are open and the students are inside (or in their way to) the schools, the procedure using the developed service will be activated (Figure 59).

Figure 59: In light blue is reported the area that will be flooded, with a high probability (>75%) in the next 30 minutes. The purple squares indicate the schools. In blue (and dark red in case of culvers) are reported the main streams in the area.

Once the A4EU system provide information to the civil protection operators, a service, described in terms of communication flow in Figure 60, is activated. This service, based on TELEGRAM, allows to both receive and provide information from/to the schools and provide information about the children's safety to their parents.

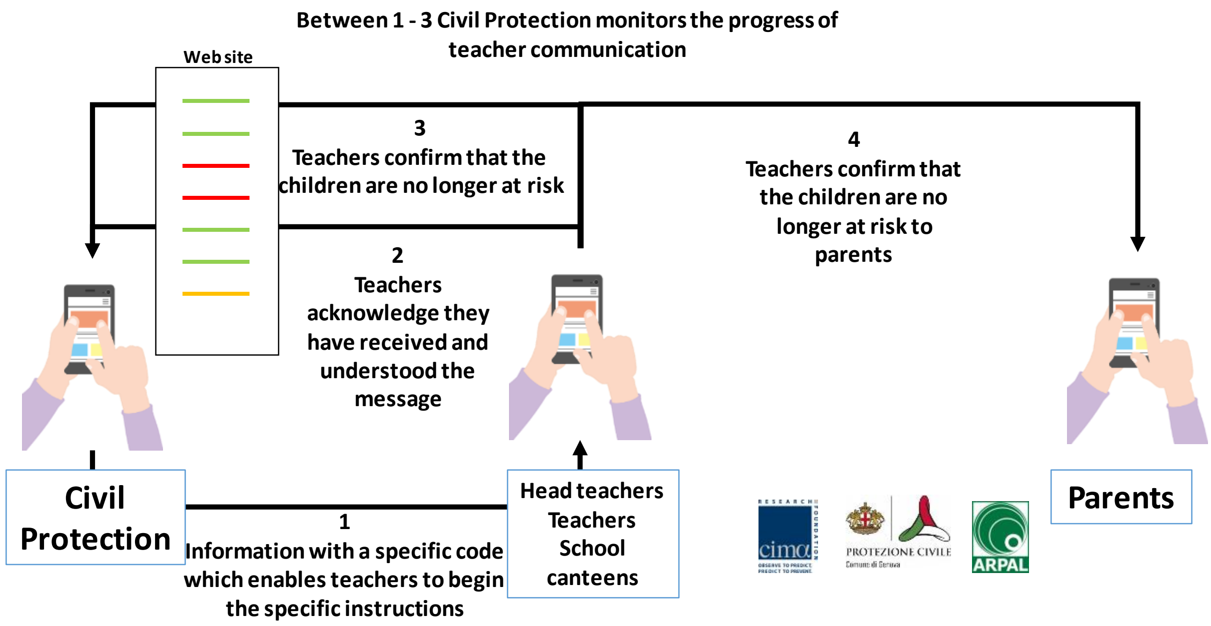


Figure 60: The communication flow between the Civil Protection, the schools and parents using A4Schools.

As reported in Figure 60, the procedure starts when the civil protection communicates to the schools (head teachers and teachers) the situation of Alarm, or another specific code defined, for which specific instructions related to the safety of people within the schools have to be followed (phase 1).

During phase 2, the teachers responsible for each specific school acknowledge that the message of Alarm has been correctly received. This is done by providing a specific feedback within the TELEGRAM bot. The civil protection receives the feedback message from each school in the municipality area while the head teachers receive information from the schools they are responsible of.

Once the children/students have reached the safety positions defined in the internal security plans, the teachers responsible for each specific school provide a feedback through TELEGRAM to both civil protection and the head teachers (phase 3).

In this moment (phase 4) the parents, that subscribed to the specific schools they are interested in, receive a message reporting that 1) their children are safe and cared by the school people and 2) take self-protection measures and do not go to the schools until the Alarm is ceased.

A user manual (in Italian), reported in Annex I, has also been provided. This user manual explains both how to install TELEGRAM for the most common systems used by the smartphones as well as how to subscribe to the specific TELEGRAM bot "scuoleBOT" used.

It can be possible to subscribe as parent, teacher, head teacher or service provider (this last option has not been activated). The subscription as parent is open and can be done by anyone interested in the service for one or more schools. On the contrary, the subscriptions as head teacher or teacher work only if the mobile phone number requesting the access has been registered as reference number for one school (in case of a teacher) or more schools (in case of head teacher). Once the registration has been correctly done the system is ready to be used.

The Municipality of Genoa is provided with an interface that enables to verify at a glance the status of each school.

Depending on the colour of the line related to a specific school, the civil protection operator can monitor in real-time how the emergency procedures have been received and followed in each place.

If the line is red the school is interested by the emergency message but has no provided any feedback to the message issued in phase 1, that is: ALARM notification received.

If the line is yellow the corresponding school provided a positive feedback related to the first notification but the feedback on the accomplishment of the actions defined by the internal emergency plan to ensure the safety of the children’s has not yet been received.

If the line is green the school confirm that all the actions defined for ensuring the children’s safety have been done.

If the line has not highlight colours the specific school is not interested by the event and related emergency. However, after the first exercises performed, the civil protection of the Municipality of Genoa decided that by default all the schools will be interested in case of an emergency in the Genoa city.

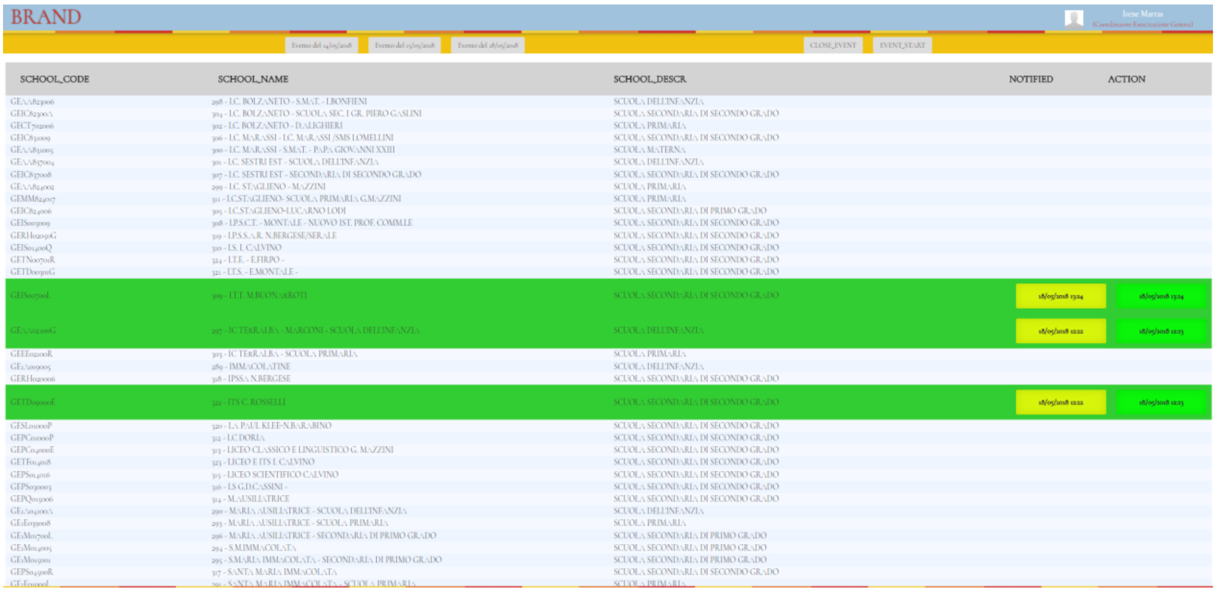


Figure 61: A4Schools system in the Municipality of Genoa civil protection headquarters. The image shows a report of the safety situation during an exercise (June 2018). In this case all the interested schools (3) provided a timely and correct feedback (green line). If no feedback from a specific school is received the line will be red while will be yellow if the first feedback has been provided but the second (children in a safe position) has not (still) been issued.

2.4.3 Simulations and results

The system was evaluated during a full-scale exercise in May 2018. In this exercise CIMA operators were in the schools that participated in the development of the A4Schools as well as in the Municipality of Genoa civil protection headquarters.

One week before the exercise, there was a meeting with the local stakeholders group (head teachers, teachers and parents), where detailed instruction for using the TELEGRAM bot was provided and a Q&A session was organized to clarify some technical aspects of the system and provide further support.

The aim of the local stakeholder's team was to explain to small groups of parents and teachers about the availably of A4Schools, its features and its use. Using this peer-tutoring approach we tested also a way of diffusing the A4School system not directly from the central authority but through colleagues or parents (peer) that have the same role and responsibilities.

A user manual (in Italian), reported in Annex I, was provided. This user manual explains both how to install TELEGRAM for the most common systems used by the smartphones as well as how to subscribe to the specific system "scuoleBOT" used.

The manual explains also how to subscribe as parent, teacher, head teacher or service provider and how to use the service during the emergencies

The results were good, and the systems was well received by both parents and school's people.

2.4.4 User feedback

The system has been evaluated as useful by the civil protection because it allows to know where the critical situations are. By receiving positive feedback from most of the schools (often not directly interested by the flash flood event) the civil protection has an indirect feedback on where it is most probable to have criticalities. In this way the emergency operators can focus their attention and verify only these situations that are not responding or following in an incomplete way the simple feedbacks requested by the TELEGRAM bot A4Schools.

The weakest point is related to the reliability of the service during weather related emergencies. The tests done by CIMA analyzing the reliability of the cell-phone network operations and the TELEGRAM systems during major events have shown a good reliability of the service. The Civil Protection of the Municipality of Genoa is also using similar systems (based on TELEGRAM) to provide information to the population in case of weather alert. In this way, the service developed, can be integrated, once approved for the operational use, with the information systems used by the Genoa civil protection.

2.4.5 Identification of Business Case

In the framework of this case study, the commercial relevance of the products and services can be assessed through by the identification of:

1. Commercial offer to be derived from project results

2. Value proposition for the target users

As first point, a clear identification of the products and services developed and implemented is necessary in order to assess the unique selling proposition. Regarding the capability to increase self-awareness and self-protection in front of flooding risk in schools, there is currently:

- A procedural model and a messaging tool (web service, smartphone app) for school managers to inform parents about the safety status of their children and provide corresponding advice.

Based on interviews and meeting with various actors (i.e. school managers, teachers, civil society and civil protections), the solution is conceived to fulfil specific needs, framing in this way the value proposition of the service, and therefore justifying its development because aligned to the expected benefits for the stakeholders involved. The value proposition is characterised by:

- Quick adoption of operationally used and usable model: the procedural model already in use is fully implemented, fasten and improved, working in a parallel way with several entities for cross-checking tasks
- Trusted information because used / provided from trusted entities (i.e. Civil Protection and regional authority for weather-based information provision)
- Replicability: similar approaches can be easily developed for providing information in emergency related to a) other weather-induced emergencies and/or b) other groups and communities.

To pave the way for potential commercial exploitation of the solutions is necessary to identify which is the innovation content in relation to the benefit for customers/users, which.

In the following a table representing the suitability of the considered solutions to these aspects:

Table 13. Identification of Value Proposition, target users and form for exploitation

Innovation content	Communication process improvement in emergency situation, enriched with institutional information of the impact of weather conditions in schools
Potential customer/user	Schools (Head teachers, Teachers); Civil society (Parents); Municipalities
Benefit to customer/user	Wider awareness and minor reaction time (for municipalities); achieve direct information from official warning; enabling safer recommendations to protect their children and themselves (schools); safety of children in schools can be extended by informing their parents (civil society)
Relation with ANYWHERE MH-EWS	The web service is directly interfaced with MH-EWS
Potential form for exploitation	Consultancy service; Free access

3 Conclusions and commercial perspective

The products and services described in the document are reported in the following:

- A web service and desktop application to calculate an impact graph in case of thunderstorms (observed/forecasted amount of the customers without electricity, energy loss during the disruption in kWh and total costs estimation) tested by electricity transmission grid operators;
- A web service to forecast the weather impact on the road network in terms of road and circulation conditions to support decision making by food distribution companies;
- A web service tool utilizing these impact forecasts to estimate the impact on relevant logistics-related information (costs, routes, queues, velocity, etc.);
- A support tool for camp site operators based on SaaS including flood observations and forecasts, including sensor data, official warnings as well as the campsite self-protection plans;
- A procedural model and a messaging tool (web service, smartphone app) for school managers and local civil protection to inform parents about the safety status of their children and provide corresponding advice.

The setup of the WP5 case studies sets the framework to gather feedback and interactions with relevant stakeholders and end users, driving the improvement and adaptation of the aforementioned solutions.

In particular, for the electricity transmission grid operators' case study, in daily use, the users recognized that impact forecasting tools build a significant part of their daily procedure in forming an overall picture on the situation. The thunderstorm tool was found helpful in the communication center as well as in the operational center of JSE. The tool was used in communication center to provide more accurate information for the public about preparedness via web pages and in the social media. The tool is being interpreted in communication center and the information provided to the public is updated accordingly (for example, the estimation of the length of power cut). Other benefits for the communication center are in general to maintain the same awareness of the situation than the operation center.
Future improvements and additions to the tool comprises: number of faults calculated to the whole South-Savo municipality area; implementation to JSE's own system instead of an additional web service; speed and usability of the interface; automatic updating of the interface in every 5 minutes.

For what concerns the logistics transportation case study, the end user is the Council of Food distribution Companies of Catalonia (CEDAC), represented by one of its associates. In collaboration with CEDAC, the needs to be covered by the application were analysed from the point of view of coordinators of truck fleets. The solutions for testing purpose have been configured by implementing the Catalonia and Genoa road network based on the flood / snow impact forecasts generated in real time during the implementation period (winter 2018-2019). The developed solutions were initially not expected/intended to be included in any of the A4* tools. Because of the interest of the corresponding Civil Protection authority, a posterior inclusion have been considered.

The evaluation from the stakeholders showed that the concept and functionalities of the developed tool for forecasting the impact of high-impact precipitation events on the road network is promising and perceived as useful.
The solutions enable relevant applications both for stakeholders and municipalities such as: improved management of stocks by including impact forecast information in the operation of a logistics platform; scenarios comparative analyses from urban to regional context.

Considering the campsite operators' case study, the tool received the feedback from various campsite managers'. Flash floods products from the MH-EWS are integrated in the tool, namely "rain warnings" and "river warnings" and was configured to allow users to adjust the thresholds for each product or sensors, including people receiving automatic messages.
User evaluations of the tool are positive, they found it easy to use and to understand with no bugs reported. There was no previous similar tool in any of the campsite, so it clearly outperforms previous "human" procedures to anticipate and manage flood risk. Interesting suggestions arose, such as: the inclusion of a historical record of actions taken (for reporting purposes) or the distinction between users of full capacity and others with restricted access. Those will be taken into account in future versions of the tool.
In long term prospective, users involved in the test phase are interested in contracting the tool after the project end. Besides that, there are other Campsite Association that already showed interest in such a tool.

Finally, regarding the case study addressing schools managers and local civil protection, the system has been evaluated as useful by the civil protection because it allows to know where the critical situations are. By receiving positive feedback from most of the schools the civil protection has an indirect feedback on where it is most probable to have criticalities. Since the Civil Protection of the Municipality of Genoa is also using similar systems (based on TELEGRAM) to provide information to the population in case of weather alert, the service developed can be integrated, once approved for the operational use, with the information systems currently in use.

The value proposition of such services has been framed in order to satisfy the end-users' needs and expected benefits, therefore justifying the existence of a business case.

The shared value proposition of the products and services designed in the framework of WP5 can be represented by the following key commercial message perceived from stakeholders and users of ANYWHERE solutions:

> The hazard and impact forecasts supplied in real time by the ANYWHERE MH-EWS constitute an ecosystem promoting the development of new tools providing usable and added-value information to promote self-p* of different end-users, stakeholders and the general population

The ANYWHERE exploitation strategy is based upon a multi-layer approach, which allows for a number of viable parallel and interlinked exploitation scenarios. A natural consequence of the existence of an exploitation scenario is the necessity to develop a sustainable business model intended to cope with such multifaceted exploitation perspective. In particular, B2B2C or Business-to-Many or B2M is a marketing term for a business that sells their goods or services to other businesses as well as to consumers.

Such B2M business model can be considered as a suitable framework to reach both civilian population and commercial companies in order to reduce their vulnerability to high-impact and extreme weather events, enabling further services.

In alignment with the potential exploitation routes of the ANYWHERE project, the exploitation scenarios linked to this type of business model are those related to the provision of **direct informational services and tools to citizens and companies enabling self-preparedness and self-protection and enhancing their proactive capacity of response to extreme weather-induced risks**.

A draft representation of a suitable business model for self-p* products and services is reported, following the canvas methodology definition (Figure 62). Such business model is in line with the definition of one of the potential exploitation routes of ANYWHERE project, analysed in the framework of WP7 and comprised in deliverable D7.4 “Innovation Exploitation Plan”.

<table>
<tr><th>5-Key partners</th><th>1-Key Activities</th><th>2-Value proposition</th><th>4-Customer Relationships</th><th>3-Customer segments</th></tr>
<tr>
<td rowspan="3">✓ MH-EWS developers and providers
✓ Third party developing tools</td>
<td>✓ IT infrastructure and software development and maintenance
✓ Self-protection info & services management: collection of specific processing requests or local data to run the models/tools
✓ Platform management
✓ Data acquisition</td>
<td rowspan="3">✓ Combination of information from MH-EWS and others meteorological tools, improving and expanding existing systems
✓ Hazard indications
✓ Improve decision making
✓ Improve response planning
✓ Provision and access of informational services
✓ Environmental risk impact reduction
✓ Adaptable to different types of needs
✓ Free open source based platform (for some users)
✓ Continuously upgraded, serviced and guaranteed platform (for commercial companies)</td>
<td>✓ Automated service
✓ Online Communities
✓ Co-creation</td>
<td rowspan="3">✓ Civilian population
• Sites to secure (Hospital, school, camping areas)
✓ Commercial companies
• Finnish power transmission companies
• Association of food distribution companies of Catalonia</td>
</tr>
<tr><th>6-Key resources</th><th>7-Channels</th></tr>
<tr>
<td>✓ IT infrastructure and software
✓ Software developers
✓ Intellectual property
✓ Data center</td>
<td>✓ Technology centres
✓ Public authorities
✓ Advisory companies
✓ Tailored web page
✓ E-mail and SMS
✓ MOBILE APP to receive push messages
✓ Social networks links</td>
</tr>
</table>

Figure 62: B2M business model suitable for self-p* products and services developed in the context of WP5

4 References

Crevier, L.-P., Y. Delage, 2001: METRo: A new model for road-condition forecasting in Canada. Journal of Applied Meteorology, 40, 2026-2037.

Fingrid (2018), Sähkön siirtovarmuus kantaverkossa pysyi korkealla tasolla vuonna 2017, Report, Finland's transmission system operator.

Goodwin and Pisano (2004), Weather-Responsive Traffic Signal Control.

KKV (2014) https://www.kkv.fi/en/facts-and-advice/defects-and-delays/power-cuts/, Report, Finnish Competition and Consumer Authority.

Huertas, F., 2019: Desenvolupament i aplicació d'un model numèric per a la previsió d'acumulació de neu en carreters. MEng Thesis, Universitat Politècnica de Catalunya, 95 pp.

Kangas, M., M. Heikinheimo, M. Hippi, 2015: RoadSurf: a modelling system for predicting road weather and road surface conditions, Meteorological Applications, 22, 544-553.

Láng (2017) Myrskyjen luokittelua ja vaikutuksia sähköverkkoihin Suomessa. MSc. Thesis, University of Helsinki, page 5.

Rossi P.J., V. Hasu, J. Koistinen, D. Moisseev, E. Saltikoff, A. Mäkelä. 2014: Analysis of a statistically initialized fuzzy logic scheme for classifying the severity of convective storms in Finland, Meteorological Applications, 21, 656–674. DOI: 10.1002/met.1389 R. Tervo, J. Karjalainen and A. Jung, "Short-Term Prediction of Electricity Outages Caused by Convective Storms," in *IEEE Transactions on Geoscience and Remote Sensing*. doi: 10.1109/TGRS.2019.2921809 Ukkonen, P., & Mäkelä, A. (2019). Evaluation of machine learning classifiers for predicting deep convection. Journal of Advances in Modeling Earth Systems, page 11 .

Willumsen, L.G. (1978) Estimation of an O-D Matrix from Traffic Counts – A Review. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Annex I: User Manual of Telegram

DOWNLOAD DELL’APPLICAZIONE TELEGRAM E UTILIZZO DEL BOT **SCHOOL**

Sommario

Introduzione

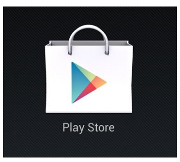
Telegram è un servizio di messaggistica istantanea simile a Whatsapp.
La differenza tra le due applicazioni è che Telegram, a differenza di Whatsapp, viene distribuito come software libero.
Questo permette di poter creare numerose funzionalità aggiuntive rispetto a Whatsapp, nel nostro caso ci concentreremo maggiormente sui **Bot**.
I Bot sono degli account Telegram, gestiti da un programma, che offrono molteplici funzionalità con risposte immediate e completamente automatizzate (sostanzialmente è come interagire con un utente virtuale).

Scaricare Telegram su Smartphone

Innanzitutto cerchiamo di capire come effettuare il download dell'applicazione per la messaggistica su mobile.
Di seguito verrà spiegato nel minimo dettaglio come procedere allo scaricamento su Android e iOS.

Android

Se stai utilizzando uno smartphone basato su Android puoi scaricare ed installare Telegram attraverso il Play Store, lo store ufficiale delle applicazioni per il suddetto sistema operativo.
Per cercare il Play Store all'interno del telefono occorre recarsi sulla home e cercare di trovare l'icona del Play Store (il sacchetto bianco con il simbolo "play" stampato sopra):



Se non riesci ad individuare il Play Store facendo così come ti ho appena spiegato, recati nel menu in cui ci sono tutte le applicazioni installate sul dispositivo e cercalo li.

Una volta visualizzata la schermata principale del Play Store, clicca sulla lente d'ingrandimento che si trova in alto sulla destra, digita telegram e seleziona il nome dell'applicazione fra i risultati della ricerca che ti vengono mostrati. In seguito, pigia sui pulsanti Installa e Accetto per scaricare Telegram sul tuo smartphone o tablet:

Una volta completata la procedura di download e di installazione di Telegram, clicca sul pulsante Apri nella finestra del Play Store per iniziare immediatamente a sfruttare l'app.

In alternativa, puoi avviare Telegram cliccando sulla sua icona (quella con lo sfondo azzurro e l'aeroplano di carta in primo piano) che trovi nella schermata principale del tuo device Android oppure nel menu in cui vengono raggruppate tutte le applicazioni che sono state installate.

iOS

Per gli utenti che invece utilizzano un dispositivo iOS, può essere effettuato il download di Telegram tramite l'App Store, lo store ufficiale delle applicazioni presente sui device basati sul sistema Apple.

Per scaricare Telegram sul tuo dispositivo devi dunque afferrare quest'ultimo, accedere alla sua home screen, aprire l'App Store (l'icona azzurra con la lettera "A" al centro che si trova nella home screen):

Una volta individuato l'App Store, occorre cliccare sulla scheda Cerca che sta in basso a destra, digitare telegram nell'apposito campo in alto e cliccare sul pulsante Cerca annesso alla tastiera virtuale a schermo:

Successivamente cliccare sull'icona dell'applicazione dai risultati di ricerca che vedi comparire:

Successivamente occorre cliccare sul bottone Ottieni e poi su quello Installa:
Per concludere, digita la password del tuo ID Apple (oppure poggia il dito sul sensore Touch ID, se il tuo dispositivo lo supporta) in modo tale da avviare la procedura per lo scaricamento.
Una volta ultimata tutta la procedura di download e d'installazione, clicca sul pulsante Apri apparso a schermo per iniziare subito a massaggiare con Telegram sul tuo device. In alternativa, puoi avviare l'applicazione pigiando sulla sua icona che è stata aggiunta nella schermata home del dispositivo.

Primo accesso a Telegram

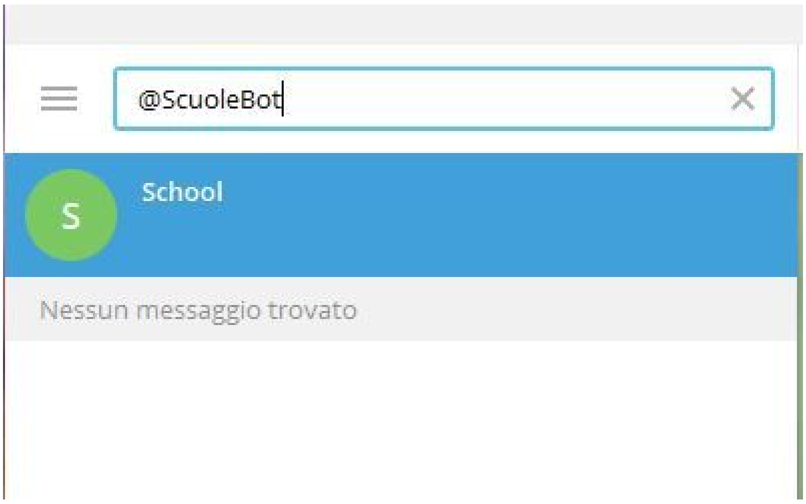
Una volta che l'applicazione è installata occorre fare il primo avvio e seguire le procedure indicate.
Una volta effettuata la registrazione, ti basterà cliccare su 'inizia ad inviare messaggi' per iniziare le conversazione con altri utenti (sia reali che virtuali).
Di seguito vengono elencati i passaggi per effettuare la registrazione:

1. Digita il tuo numero di cellulare sulla stringa in alto e poi salvalo premendo sul segno di spunta posto a destra
2. Inserisci il codice di sicurezza di 5 cifre, che ti verrà inviato via SMS, per confermare il tuo numero di telefono
3. Nella schermata successiva, potrai inserire il tuo nome utente (il cognome è facoltativo)
4. A questo punto è possibile iniziare la tua la tua prima conversazione, cliccando sull'icona blu della matita, posta:
    a. in basso a destra per gli utenti **Android**.
    b. in alto a destra per gli utenti **iOS**.

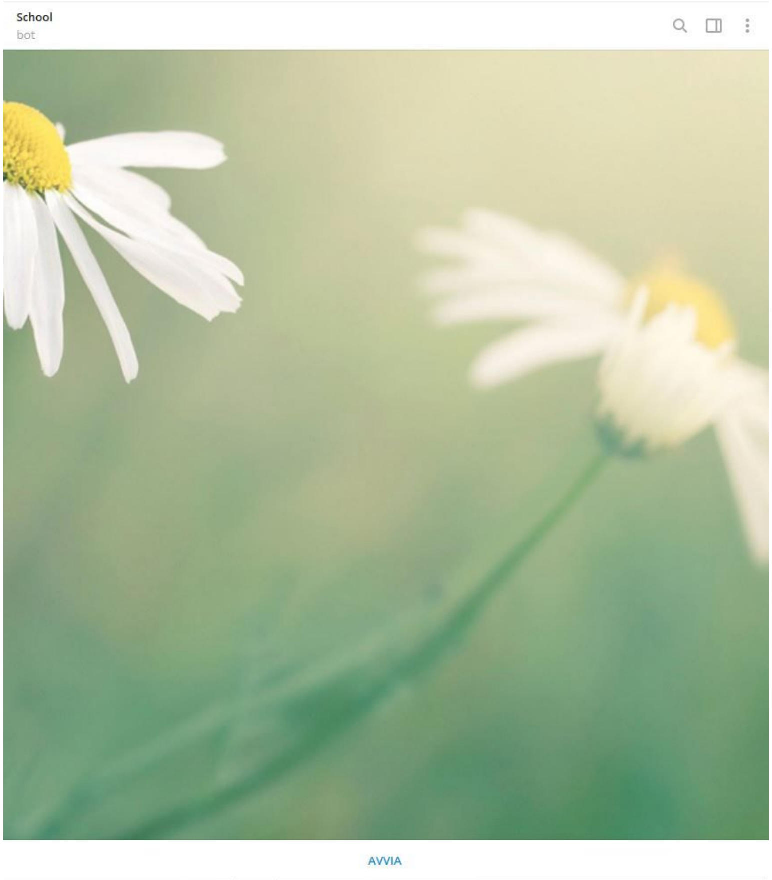
A questo punto, una volta cliccata la matita, si possono ricercare gli utenti inserendo il loro numero di telefono (per utenti reali) oppure '@' seguito dal nickname (sia per utenti reali che virtuali), sempre nello spazio indicato con la lente d'ingrandimento (barra di ricerca), e iniziare così la prima conversazione attraverso la classica schermata da chat.

Ricerca del Bot **School**

Come accennato precedentemente, attraverso Telegram è possibile ricercare non solo utenti reali ma anche utenti virtuali che rispondono automaticamente a seconda del tipo di risposta fornita.
In questa guida ci dedicheremo in modo particolare al Bot **School** dedicato alla gestione dei flussi di comunicazione tra la Protezione Civile del Comune di Genova e le singole scuole durante la Fase di Emergenza per il rischio alluvione.
Per poter ricercare il **Bot** occorre, una volta entrati all'interno dell'applicazione e aver cliccato sulla matita, (vedere capitolo **Primo accesso a Telegram**) inserire nella barra di ricerca la stringa **@ScuoleBot**:



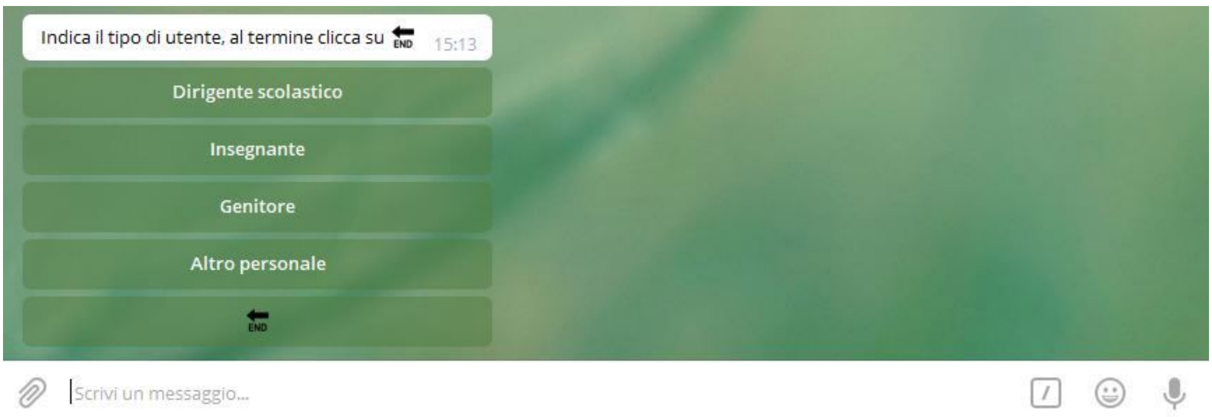
A questo punto, una volta che apparirà il Bot nella lista, occorrerà cliccare su di esso per poter iniziare ad interagire con lui.
Una volta cliccato sul Bot apparirà una schermata simile:



A questo punto occorrerà cliccare sul pulsante **AVVIA** per iniziare la conversazione col nostro utente virtuale.

Utilizzo del Bot

Una volta cliccato il pulsante **AVVIA**, il Bot inizierà a chiederci la tipologia di utente a cui apparteniamo:



Le tipologie di utente sono essenzialmente 4.
Una volta selezionata la tipologia a cui apparteniamo occorre cliccare su **END** per confermare.
A questo punto il Bot si comporterà in maniera differente a seconda della tipologia di utente da noi selezionato:

Dirigente scolastico

Se abbiamo selezionato questa tipologia di utente, una volta cliccato su **END** il Bot ci chiederà di condividere il numero di telefono.
Cliccando su **OK** e dando il consenso per la condivisione il sistema controllerà se il vostro numero corrisponde a quello presente nell'anagrafica e in caso di esito positivo, vi confermerà il Login.
A questo punto, nel momento in cui il COC passerà allo stato di ALLARME, riceverete all'interno del Bot un messaggio che vi avviserà dell'avvenuto passaggio.
Successivamente, il Bot mostrerà , in un unico messaggio, la lista di tutte le scuole e sotto ad ogni scuola vi saranno due voci:

1. Ricezione Stato di ALLARME (Notifica dell'avvenuta ricezione del passaggio alla Fase Operativa di ALLARME da parte del Comune)
2. Alunni messi in sicurezza (Notifica dell'avvenuta messa in sicurezza degli alunni)

A quel punto il Dirigente avrà a disposizione un pulsante **Aggiorna**.
Cliccando sul pulsante**,** se una scuola ha notificato la lettura del passaggio allo stato di ALLARME oppure ha messo in sicurezza gli alunni, il Dirigente potrà vedere la data e l'ora in cui sono state eseguite le relativa azioni per ogni scuola di sua competenza.
Una volta ricevute le seguenti notifiche, si riceverà un ultima notifica in merito al passaggio alla Fase operativa di CESSATO ALLARME.

Insegnante

Una volta selezionata questa tipologia di utente, una volta cliccato su **END** il Bot ci chiederà di condividere il numero di telefono.
Cliccando su **OK** e dando il consenso per la condivisione il sistema controllerà se il vostro numero corrisponde a quello presente nell'anagrafica e in caso di esito positivo, vi confermerà il Login.
A questo punto, nel momento in cui il COC passerà allo stato di ALLARME, riceverete all'interno del Bot un messaggio che vi avviserà dell'avvenuto passaggio.
Una volta ricevuto il messaggio, dovrete notificare di aver ricevuto e letto il messaggio cliccando sul pulsante **Notifica**.
Una volta cliccato, la notifica verrà inviata al COC e al Dirigente e il Bot vi chiederà di cliccare sul nuovo pulsante "**Alunni messi in sicurezza**" per confermare di aver eseguito le azioni previste dal Piano di Emergenza.
Cliccando sul seguente pulsante, il sistema chiederà se si vuole confermare:

1. Cliccando su **SI** verrà inviata la notifica a tre utenze:
    a. Il Dirigente scolastico
    b. Il COC
    c. I Genitori della relativa scuola
2. Cliccando su **NO** si tornerà al pulsante "**Alunni messi in sicurezza**"

Una volta che le utenze sono state avvisate e gli alunni sono stati messi in sicurezza, si riceverà un ultima notifica in merito al passaggio alla Fase operativa di CESSATO ALLARME.

Genitore

Selezionata la seguente tipologia di utente, una volta cliccato su **END** il Bot ci mostrerà la lista delle scuole.

A questo punto dovremmo selezionare quelle in cui sono presenti i nostri figli e, una volta selezionati gli istituti e cliccato nuovamente su **END** per confermare, si rimarrà in attesa del messaggio di messa in sicurezza degli alunni da parte degli insegnanti.
Per cambiare le scuole selezionate, occorre scrivere **scuole** utilizzando la tastiera virtuale dell'applicazione:

Una volta scritto e inviato il testo, il Bot mostrerà nuovamente la lista delle scuole come precedentemente mostrato.
A quel punto sarà possibile andare a deselezionare le scuole scelte precedentemente andando a selezionarne delle nuove.
Una volta terminata la procedura, clicchiamo nuovamente su **END**.

Altro personale

La seguente tipologia di utente non richiede particolari interazioni col Bot.
Di conseguenza, una volta selezionata la seguente tipologia, occorrerà rimanere in attesa del messaggio di passaggio allo stato di ALLARME da parte del COC.
Una volta ricevuto quel messaggio, si riceverà l'ultima notifica in merito al passaggio alla Fase operativa di CESSATO ALLARME, quando il COC deciderà di chiudere l'evento in corso.