Wildfires and WUI fires emergency planning towards a next generation of decision support systems

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Abstract: *Ensuring people safety in case of wildfires, and WUI (Wildland-Urban Interface) fires in particular, implies complexities, where land management, organisation of firefighting services and emergency management should be integrated having one consistent vision. In the wildfires where most of the casualties occurred, one or more of those elements were found faulty. Some of the worst disasters occurred in the 2017 – 2019 period have shown clearly that emergency management is pivotal to save human lives.*
The following considerations, presented in the Human Behaviour and Evacuation Modelling GEO-SAFE Workshop (Greenwich-UK February 20th, 2020), highlight that a new approach to emergency planning, based on DSS fed by simulation models, can improve emergency management .

1. Wildfires vs. building evacuation: a firefighter's perspective

Wildfires and WUI fires often menace the safety of all the people who happen to be in the areas exposed to fire and smoke propagation. The number of deaths caused by the fires that occurred between 2017 and 2019 in Portugal, Greece and California has shown how important it is to take care of the ability to fight the fire, of the safety of the rescuers and of the safety of people who reside or transit in the areas affected by the fires.
In table 1 is presented a list, which is not complete, of wildfires occurred in the recent years that have caused the evacuation of large numbers of persons, or of entire communities. The selected events highlight the variety of scenarios (wide area evacuation with tens of thousands of evacuated people with or without casualties, small areas with tens of deaths, sudden spread of the fire or slow onset of the fire threat) and the need of flexible and condition-dependent emergency planning, even though the acceptance of the need of such planning is still lacking.
A comparison between the emergency plans prepared for buildings and the territorial plans can help to emphasise the limits that affect the common approach to people safety in case of wildfires. Despite the numerous differences between structural fires and wildfires/WUI fires, there are significant similarities that can help to improve the approach to wildfires evacuation planning. The alerting problem is an important part of the problem. When a fire starts in a building, a fire detection system warns about the risk and allows the alarm to be raised automatically or through mediation by human intervention. Similarly, in the case of wildfires, detection methods have been developed over time, ranging from human surveillance to automatic systems to detect the fire as early as possible, so as to allow people to carry out the actions that can make them safe.
In wildfires, like in buildings, safe places are important. In both cases, people should leave the place at risk, but this is not always possible, so that specific measures which allow to safely remain in the same place have to be studied.

Evacuation planning highlights some important differences about the actions to be take too. Evacuees usually identify escape routes in a building thanks to well-known standard signs that guide them to safety. In wildfires normally it is not possible to indicate which routes lead to safety: depending on the place where the fire starts, the slope and aspect of the terrain, and the intensity and speed of the wind, as well as the state of the biomass that feeds the fire, its spread put different areas at risk.
Wrapping up such considerations, in order to reach a comparable level of reliability and efficiency as for evacuation planning in buildings, in case of wildfire we should improve the capacities of (a) detecting timely the fire, (b) alerting people and (c) being able to provide correct instructions to the evacuees about which route they have to follow to reach a safe place.
In the opinion of the Authors, the specific features of the wildfire/WUI fire evacuation, briefly summarised, should lead Authorities to consider the emergency planning as the set-up of a decision support system (DSS) more than the writing of static documents, that are usually required by the applicable rules and standards.

period	area	evacuated	reference
2019 - 2020	Southern Australia	thousands of residents and tourists	https://en.wikipedia.org/wiki/2019%E2%80%9320_Australian_bushfire_season
2019	Canary Islands - Spain	thousands of residents	https://en.wikipedia.org/wiki/2019_Canary_Islands_wildfires
2019	Alberta - Canada	10.000	https://en.wikipedia.org/wiki/2019_Alberta_wildfires
2018	Mendocino - California -USA	52.000	https://en.wikipedia.org/wiki/Camp_Fire_(2018)
2018	Attica - Greece	700	https://en.wikipedia.org/wiki/2018_Attica_wildfires
2018	Ventura and Santa Barbara Counties - California - USA	over 104.607	https://en.wikipedia.org/wiki/Thomas_Fire
2017	Pedrogao Grande - Portugal	villages with some 20.000 residents	https://www.express.co.uk/news/world/999442/Portugal-fire-fires-Europe-holiday-Algarve-evacuation-wildfires-latest-today
2016	Fort McMurray, Alberta, Canada	88.000	https://en.wikipedia.org/wiki/2016_Fort_McMurray_wildfire

Table 1: list of some of the wildfires that prompted an evacuation in the period 2016-2020. In the case of California, Portugal and Greece, tenths of persons have died due to late or poorly planned and carried out evacuation.

2. Improving emergency planning

Up to a few years ago, it was unthinkable to foresee into the emergency planning the possibility to timely instruct people on the route they should take to ensure their safety. Technologies able to calculate with the required accuracy and speed, the propagation of the flame front and of the smoke basing on updated data were not available. Notwithstanding the communication systems' capability to reach all those who happen to be in a certain area are available from some years, it was not appropriate to provide instructions to them, due to the unavailability of updated data from the area that could be affected by the combustion products. Nonetheless, addressing the alert to everybody can be considered, for more reasons, an issue to be solved: the ageing of the population[1], the growth of international tourism (with large number of people that visit areas without having a sufficient access to safety information or knowledge of the places[2]) and the increased general sensitivity towards individual safety must be considered a part of the problem.

[1] In the October 12Th, 2017 fire in Sonoma and Napa valley - California, the average age of victims was 79. http://www.govtech.-com/em/disaster/California-Firestorm-Took-Deadly-Toll-on-Elderly-Average-Age-of-Victims-Identified-so-far-is-79.html

[2] An example of evacuating of thousands of tourists is the fire of the summer seasons in France (2017) and Spain (2016): https://www.independent.co.uk/news/world/europe/benidorm-fire-hundreds-evacuated-holiday-villas-spain-east-coast-javea-xabia-a7226001.html

Sensor networks off the shelves are suitable for providing adequate real-time data on the most important parameters for real-time fire and smoke propagation models. They allow emergency managers to make decisions based on sufficiently reliable simulations of the spreading of the fire.
Moreover, real-time communication systems A2C (Authority to Citizen) allow to provide prompt and accurate information to everyone who could be affected by the combustion products. Such systems, however, would not be sufficient to allow Authorities to take decisions during an emergency regarding what citizens must do to reach a safe place. One more factor has to be introduced within the emergency planning.

3. The time factor in emergency planning

Decisions that Authorities should take during an emergency cannot ignore the time factor. Exactly as it happens in structural fire safety engineering, one of the most important data to be considered is the time available to reach a safe place (ASET - available safety egress time), that is the time needed for the combustion products to make an enclosed space untenable. Such time, in the fire safety assessment process, is compared with the RSET (requested safety egress time), that is the time needed for people to evacuate a building and reach a safe space. In a safe building the difference ASET-RSET must be greater than zero and its value is linked to the prospected safety factor of the project.
The current availability of propagation models for wildfires already allows to adopt the very same approach used when dealing with evacuation planning. Without this assessment it would be a gamble to order the evacuation of people. Fig. 1 wants to illustrate the advantages that the comparison between the time needed to evacuate and the propagation over time of the fire front and smoke cloud could bring to the relevant Authorities.
The NFPA Code 1616 in the 2020 Edition recognises (Annex D (Mass Evacuation Requirements Analysis)) the need to take into account the duration of the evacuation, going further on. Annex D of the Code, in fact, states that: "*The decision to evacuate might be prompted by advice based on the real-time threat assessment concerning a threat to the municipality or a private or commercial concern*".
In other words, in the specific field of wildfires and WUI fires, emergency planning can be considered more and more as a tool for relevant authorities to assess in real time what's happening and which is the best decision to take to save lives using modelling tools, rather than through the creation, approval and eventually update of a static document.

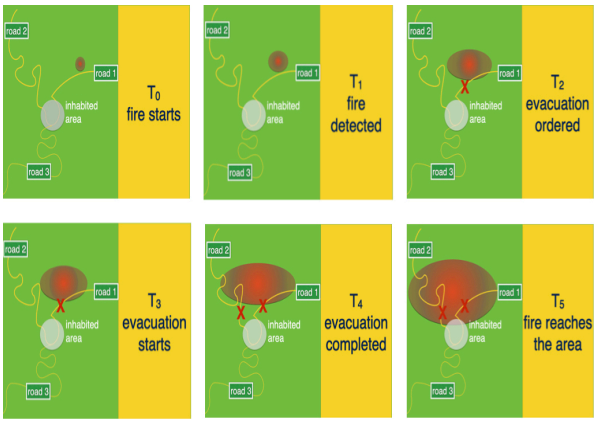

Figure 1 - A scheme explaining the need to consider the evolution over time of the evacuation to be compared with the spread of the fire. At T_0 the fire starts and at T_1 is detected. At T_2 the evacuation is ordered, and T_3 the evacuation starts. In the meanwhile, the fire has made untenable the conditions of road 1 (T_2) and road 2 (T_4). When the fire has reached the town (T_5) the evacuation must be completed (T_4). Safety conditions are met when $T_4 < T_5$.

4. Discussion

Research is still needed in some specific fields. In reference [2] are described some of the aspects that require further research (such as quantifying the response phase behaviour of people, physical walking capabilities of pedestrians over long distances, the vehicle-pedestrian interaction during evacuations, the speed of the calculations and the quality of the simulation tools).
We believe that one more aspect should be considered. Deciding in real time about human lives poses responsibility issues that hardly could be accepted by the managers in charge. Such problem has cultural aspects that could reveal to be the hardest step to take without a development of the entire discipline that also takes into account training, information and instruction over the effective scopes of innovation.

5. Conclusions

Managing emergency data from different sources in real time (high-quality weather forecasts, evacuees localisation, traffic conditions etc) and using information systems that must continuously interoperate with each other require an important research and experimentation effort. But, a cultural issue should be considered too. The different Authorities involved in the chain need to be aware of the advantages

that the new approach offers. More specifically, since a new generation of decision support tools allows to save lives through real time assessment about evacuation alerting and instructions, new responsibilities could prevent from the adoption of such systems. The Authors believe that informed choices based on objective data could provide a decisive improvement, when compared to the current methods.
To this end, the Italian National Fire Corps (CNVVF - Corpo nazionale dei Vigili del Fuoco), which is involved in the research activity with the EU co-funded FIRE IN (Horizon 2020 grant agreement n° 740575) [3], IN PREP (Horizon 2020 - grant agreement n° 740627) [4] and GEO SAFE (MSCA-RISE - Marie Skłodowska-Curie Research and Innovation Staff Exchange) [5] actions, has recognised the need to improve also the cooperation with the local authorities (regioni) which are in charge of forest fire fighting policies.
Without an effective cooperation with the authorities involved in the management of wildfires and WUI fires (including prevention, preparation, prevision and response), and, possibly, specific technical regulations for wildland/WUI fire prevention, the investments in research would have poor chances to improve the safety level at the territorial scale.

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