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# Could a remotely operated UAV fleet improve emergency response?

A. Avi*, G. Quaranta

Dipartimento di Scienze e Tecnologie Aerospaziali, Politecnico di Milano, via Giuseppe La Masa, 34, 20156 Milano MI

arrigo.avi@polimi.it, giuseppe.quaranta@polimi.it

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**Abstract.** Unmanned aerial vehicles could reduce risks in emergency response missions. The UAV firefighter team of Provincia autonoma di Trento proposes a new concept of operations. A fleet of drones placed in strategically selected locations and operated from the main headquarters in Trento. The first UAV, with a docking station, was placed on Marmolada glacier for trial.

## Introduction and motivation

Unmanned aerial vehicles are changing many aspects of our society. We have examples of constructions, surveys, rescue, etc. One of the most important aspects is the reduction of the risks compared to manned aircraft, other things are lower costs and automation.

The civil protection system of Provincia autonoma di Trento [1] (a region in the north of Italy, known for the Dolomiti mountains) is complex and articulate. There are lots of different actors: more than 5000 volunteer firefighters, a professional brigade, alpine rescue teams, red cross groups, etc. One of the main objectives of this organization is rescuing people and about that, and the coordination between different teams is paramount. Since 2015 a team of the firefighter professional brigade regularly use UAVs as an important tool. They are involved in many activities like searching for missing people, wildfires, notable accidents, surveying landslides and cliffs, and other important activities for prevention management.

In particular, the three most important activities performed are:

- Missing People

  The deployment of UAV teams during the search for or missing person missions is standard [2], coupled with local firefighter volunteer brigades. Response time is one of the more challenging aspects of this type of operation: the team moves from Trento headquarters to the site of the last known position. This could take more than an hour and pose a risk against a successful result. Furthermore, sites are in narrow valleys with few roads, some in a bad condition.

- Hydrogeological risk

  In the Alps region, it is necessary to monitor the environment against climate change, especially hydrogeological risks. UAVs conducted a lot of surveys related to hydrogeological management, assessment of damages, and risk assessment. Monitoring activities are ever more important and require a higher frequency, so UAV could be an effective platform to do the monitoring in a cheaper, safer and more effective way.

- Situational awareness

  The frequency and cost of natural disasters are increasing worldwide [3]. It is paramount to have a fast and reliable way for situational awareness. It is essential to have accurate information from the disaster sites for an effective high-level decision-making process. This is one of the most demanding activities to be performed, it requires lots of personnel

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(that could be already involved in rescuing people) and equipment. Currently, there are some systems that could give an overview of the situation. There are two systems: a fleet of steerable cameras that cover only 20% of the entire territory, and a fleet of sensors that could give only punctual information. Lacking coverage and punctiform information leads often to poor situational awareness.

**Proposed Concept of Operations**

Following the previously highlighted problems, a new concept of operations was proposed. A fleet of drones, that remains inside docking stations, placed in strategically selected locations and operated from the main headquarters in Trento. Docking stations guarantee a safe takeoff and landing area, recharging, and storage. In this way, it is possible to have a distributed system that could have a larger coverage area (up to the entire territory) and almost real-time response time. The UAV fleet is composed of a docking station, UAV, a data network, and interfaces.

The *docking station* is the logistical part of the system. It provides a safe takeoff-landing area with precision landing aids, recharging or replacing systems for batteries, and automatic systems for payload change. It is connected to the data network and acts as a datalink repeater for UAVs.
*UAV* is the frontline object of this system, plays an important role in terms of reliability and availability in marginal weather conditions like often is during natural disasters.

*Data networks* have a key role in the entire system. It needs to guarantee a safe and reliable way to communicate with the UAV and with the docking station. Another important role is the deployment of information for other people involved in operations: video feed for firefighters, repeater for communications, and redundant datalink with the main operating center.

*Interface* is the link between pilots and UAV, it should be customized based on the different missions in which will be used.

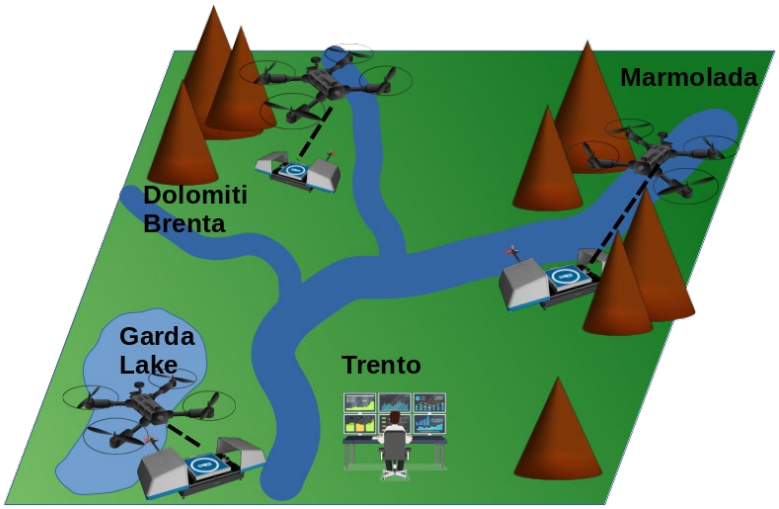


*Fig. 1 - concept of operations*

**Feasibility study and proposed implementation**

A remotely located fleet of drones is an intensive initiative to develop. It is important, and mandatory for a public administration, to do a feasibility study to evaluate sustainability in the most general way.

The deployment of many docking stations is expensive, so it is important to evaluate how much the UAV network could be used for different activities. To evaluate the feasibility of the proposed UAV network that, a session to present the project was organized with members of the Civil Protection Department: geological, forest, and water management services. After the meeting a

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brief questionnaire was sent, regarding which services were interested in using the remotely operated UAV network and in particular:

- how many areas interested and extent;
- how many yearly operations;
- distance from villages;
- time of operations (h24/7, seasonal, real time, programmed);
- objectives;
- data needed (RGB, lidar, multispectral, video feed...)

5 forms were collected with the following outcomes:

- a fleet of UAV was an interesting idea;
- most service need programmed operations;
- services are very interested in collecting data, but don't have enough resources to process;
- almost all areas are outside of villages;
- all services need to monitor both small areas and large areas.

The most important outcome of this questionnaire was the number of operations needed by every service: at least 250 operations every year; this information highlights that a sustainable design of the network could be achieved.

Finding a compromise to satisfy all the preceding requirements is not simple. A current solution that involves COTS components already available on the market could be depicted. In particular:

- UAV should have an endurance of at least 2 hours, and range of 15 kilometers;
- it is necessary to have at least 12 docking stations with UAV [4];
- it is necessary to deploy a digital data radio network [5].

With these requirements, sustainability could be reached because the fleet covers the territory of Trento region, every UAV could reach every location inside its working area in less than 10 minutes, and 12 docking stations could guarantee reliability with lots of backup alternatives.

In terms of economic evaluation, the proposed solution requires initial investments of about 2.500.000 €, and yearly costs of 85000 €.

The management of this proposed solution needs some dedicated human resources: there should be a team of 10 people because it is necessary to have at least 2 pilots H24/7 and a team for maintenance.

All these evaluations led to consider this system sustainable and effective for a regional firefighter department.

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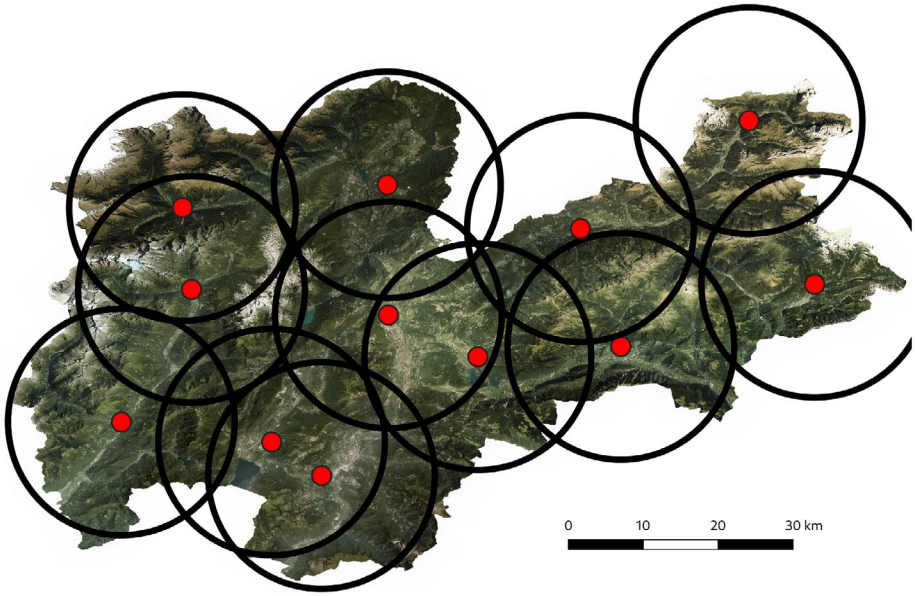


*Fig. 2 - proposed docking station network*

In a feasibility study [6] it is important to evaluate alternatives. Three options were analyzed:

- option *zero*: do nothing, it isn't an actual solution, all the troubles highlighted before remaining unchanged;
- option *one UA*: deploy a very expensive and performing UAV that could fly directly from main headquarters with endurance of many hours, simplest solution but with no backup (only one UA in one location);
- option *UAV everywhere*: deploy lots of UAVs managed by a local team, it is almost impossible to manage due to the large team and due to people already involved in rescue operation couldn't be available for UAV piloting.

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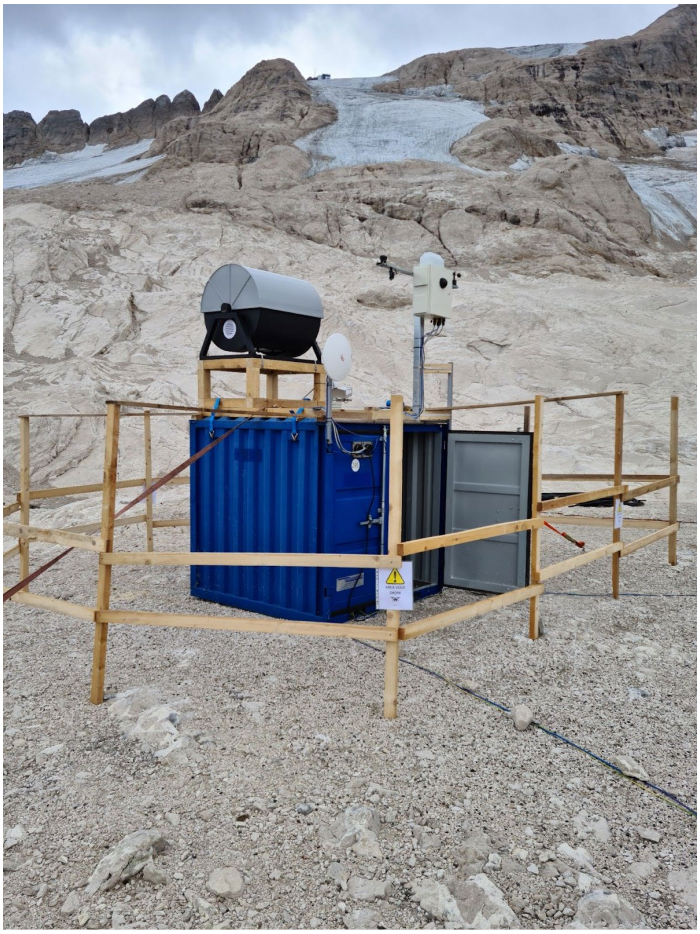

*Fig. 3 - Marmolada trial*

**Trial in Marmolada**

On 3 July 2022, a collapse involving the glacier of Marmolada, it took 11 lives. After that, the first UAV docking station was placed near the glacier to perform surveys on the remaining glacier. From 03 September to 03 November, the station was operational, and 37 missions were flown. Most missions were inspections of a crevasse or photogrammetric survey. This first deployment was composed of an agnostic docking station, a DJI drone and a commercial cloud interface. Managed from the headquarters in Trento, it was an important opportunity to test, in a small and simple way, the effectiveness of the proposed network.

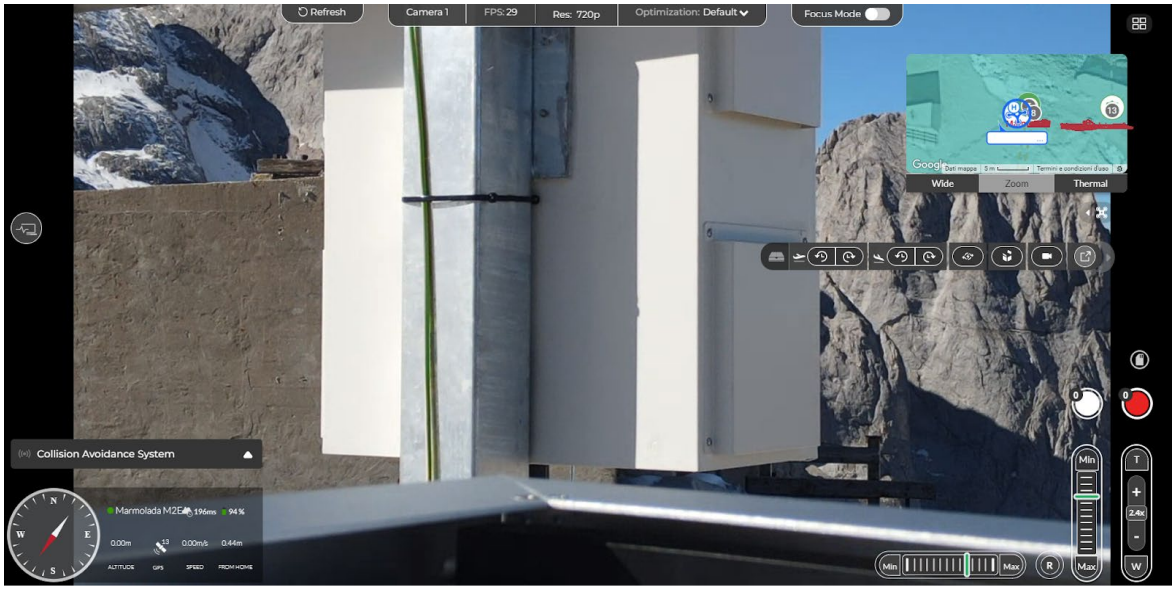


*Fig. 4 - Interface*

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