BEST DRONE PRACTICES 2020

INTERNATIONAL RECOMMANDATIONS FROM 13 COUNTRIES

The state-of-the-art 2020 best practices, techniques, tactics of drone uses for fire & rescue operations

International Emergency Drone Organization

IEDO
BEST DRONE PRACTICES REPORT

Version	Date	Page	Object
2020	March 1st 2021	All	Creation

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1. ACKNOWLEDGMENTS

We would like to thank all the contributors and editors who worked together to bring together knowledge and data necessary for the creation of this document of international recommendations on best drone practices in for all the services and associations involved in fire and rescue missions.

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We would also like to thank **our sponsors** who support the publication of this report in the global process of sharing knowledge beyond borders to help us save more lives with drones.

We thank them not only for their financial support but also for their trust, for their benevolence towards our association.

A win-win relationship is built on mutual and reciprocal respect and for us that has value, so **THANKS**.

We are always searching for new sponsors so if you are interested to support us, contact us :

info@iedo-drone.org

INTERNATIONAL ASSOCIATION OF FIRE AND RESCUE SERVICES
INTERNATIONALE VEREINIGUNG DES FEUERWEHR- UND RETTUNGSWESENS
L'ASSOCIATION INTERNATIONALE DES SERVICES D'INCENDIE ET DE SECOURS

CTIF

February 25th 2021

Letter of Support

CTIF, the International Association of Fire and Rescue Services, strongly supports the development of technology, new approaches and visions on how fire and rescue services can execute their missions faster, more efficiently and safer.

This leads to the signing of a Memorandum of Understanding between CTIF and the IEDO association. Drone technology has been used by emergency services for years, but it's still fairly recent. Not all public safety services use it today. Technological innovation and drone regulation have always been constantly evolving and adapting, but much faster than the development of best drone practices. Today, emergency services show many differences in the use of drones, between those who have become experts and those who are launching their drone program.

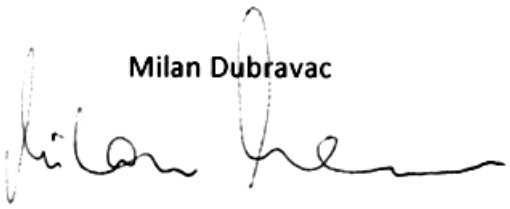
The CTIF Executive Committee has been informed about the IEDO Tactical program, which summarizes the best practices of the use of drones in 2020 concerning rescue and firefighting missions. By gathering, exploiting, analyzing, synthesizing and disseminating good practices of drone uses in the field of disaster and crisis management, a very valuable document will be created, and this to the benefit of all emergency services.

With this letter, we would like to express our full support concerning this program. We are looking forward to reading the result and offer our help with the dissemination.

With best regards

President of CTIF

Milan Dubravac



IEDO
International Emergency Drone Organization
Leadership Board

Preface

Since 2017, drones have saved more than 400 lives around the world. Many fire and rescue services and SAR associations have adapted this new technology to be more efficient and timely in decision-making.

Implementing and flying an aircraft without a pilot on board is technical and specific know-how. Conducting this remote piloting for a rescue or fire-fighting mission in an emergency and stress context requires a great deal of rigor and specific skills. In order to acquire them, one must prepare, train and practice to maintain one's achievements.

Another factor comes into play: experience. An experienced drone pilot is one who has multiplied operations, failures, successes, various contexts and environments. The sum of the lessons learned builds the experience. When this is shared, from the experienced pilot to the novice pilot, it helps to build knowledge, to modify the behavior of the inexperienced by developing his attention, his prudence, his self-confidence.

Thus, after highlighting the good practices of the drone in a rescue or firefighting situation, this report aims in particular to offer the necessary and useful knowledge for a drone pilot of a fire service or an association of search and rescue (SAR), regardless of country and language.

This report aims to shed light on the tactical use possibilities for a drone team of an emergency service but also all the missions that can be carried out by drone for a layman.

It therefore aims to disseminate the state of the art of drone practices in rescue missions and also to promote the use of the drone by all emergency, rescue and firefighting services and crisis management organizations.

President of IEDO

Vendelin CLICQUES

2. SUMMARY

In line with the philosophy of the IEDO association based on international exchange and sharing, this report summarizes best drone practices in 2020 concerning fire & rescue missions.

These various practices are the synthesis of lessons learned in the field, local emerging initiatives and common practices widespread from 62 fire and rescue services, police services (SAR actors) and rescue associations from 13 countries in the world.

This report is not exhaustive but illustrates a good part of the tactical uses of the drone in 2020 to save and preserve people, property and the environment.

The dissemination and sharing of this knowledge is intended for all rescue actors who use drone technology or who wish to start a drone program.

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3. PRESENTATION

A. Presentation of the IEDO association

IEDO, the International Emergency Drone Organization, is **an international non-profit association** with general interest approval. It is based in France, in the commune of Versailles, in the offices of the Departmental Service for Fire and Rescue of Yvelines. It was created on June 10th 2018.

It **brings together drone first responders specialists and remote pilots** from several countries, from several public safety agencies or associations.

FIREFIGHTERS | POLICEMEN | SAR VOLUNTEERS | DOCTORS & PARAMEDICS

This community has more than **600 members** (firefighters, police, paramedics, doctors, coast-guards, SAR volunteers) from **42 countries.**

THE MAIN OBJECTIVES OF IEDO ARE:

- Develop the exchange of **knowledge** and experience between emergency drone teams around the world, share feedback to improve the operational quality of each.

- Improve the **efficiency of drones** by creating working groups on the **tactical uses** of drones and field experiments

- Develop a training & certification system for **international rescue drone teams**

Our will is based on the development of exchanges of transversal way and to be able to discuss local problems, solutions and initiatives, the best uses of the drone to save lives.

All these actions are carried by the volunteer members of IEDO in a collaborative way.

IEDO is a drone community by first responders, for first responders.

www.iedo-drone.org

B. Main objective of the tactical program of IEDO

Drone technology has been used by emergency services for years, but it's still fairly recent. Not all public safety services use it today. Technological innovation and drone regulation have always been constantly evolving and adapting, but much faster than the development of drone best practices.

Today, emergency services show many differences in the use of drones, between those who have become experts and those who are launching their drone program.

The IEDO Tactical Program, launched on 1 December 2020, is an international project whose main objective is to gather, exploit, analyze, synthesize and disseminate best practices for the use of drones in the field of disaster and crisis management.

Sharing this knowledge about drone uses for rescue or fire mission will afford all emergency services (fire department, police services, SAR associations & emergency agencies) a better understanding of drone capacities and also a better efficacy in their missions.

And each public safety agency will be able to access its best practices, learn, improve its operational capabilities and be more efficient.

C. Project Description

Step 1

The first step was to gather knowledge at a country level. The IEDO staff has identified 13 persons who are IEDO members and also actively involved in public safety drone operation.

They have been tasked, as national working group coordinator, to gather knowledge from field through experience, feedback or lesson learnt from their network in their country (IEDO member or not).

A template form has been created to collect all data in the same framework. This form has been used by all working group coordinators in their network to manage data.

On the first deadline, April 1st 2020, the 13 working group coordinators started to write a national report summarizing the state of the art of tactical use of drones in their country.

Due to the COVID19 pandemic, the project schedule has been delayed quite legitimately. Since we must not forget that our national coordinators are first responders who have been on the front lines. All reports were delivered in October 2020.

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	Lt Pedro Reis
	Bruno Kekez
	Harley Peter Poulsen
	Onofrio Lorusso
	Lt Vendelin Clicques
	Junior Ferreira
	Changsik Heo
	José Luis Calvete Aguilar
	Mikael Aspelin
	Lee Newman
	Travis Calendine

Dec. 1st 2019	Creation of 13 working group
Dec. 2019 to March 2020	13 working group coordinators gathering best practices
Oct. 1st 2020	Delivery of 13 national reports

Step 2

Step 2 is about merging all data from the 13 countries in 1 document.

To summarize 13 national reports, a physical working group is needed. That's why IEDO tried to regroup the 13 working group coordinators in one place to brainstorm and work together in order to sum-up and write an international report with all data.

This international workshop about best practices was the opportunity to share knowledge and experience.

Once again, due to COVID19, this face-to-face workshop has been postponed several times and finally canceled for the year 2020. IEDO Management Board has done its best to adapt to this situation. Several small thematic working groups were created in just a few weeks to analyze the data from the 13 reports.

November 2020 to January 2021	7 thematic working groups created
January to February 2021	Synthesis and writing of the Best Practices report
March 1st 2021	Release of the IEDO 2020 Best Practices Report

Step 3

IEDO will update the IEDO Best Practices report each year from the 13 national working groups.

Of course the Leadership Board hopes this approach will be extended to many other users from many countries, and encourages any first responders using drones to participate to share their experience and knowledge with our global community.

The goal is to collectively raise the level of capabilities of each public safety drone user around the world.

D. Glossary

Abbreviation	Short description
BVLOS	Beyond the Visual Line Of Sight
ECBRN	Explosive, Chemical, Biological, Radiological and Nuclear
ELA	Emergency Landing Area
FD	Fire Department
GDRP	General Data Protection Regulation
GPS	Global Positioning System
HazMat	Hazardous Materials
IC	Incident Commander
PD	Police Department
RPIC	Remote Pilot In Command
RTH	Return To Home
SAR	Search & Rescue
TOLA	Take-Off and Landing Aera
UAS	Unmanned Aircraft System
VLOS	Visual Line Of Sight
VO	Visual Observer

4. ORGANIZATION OF A DRONE TEAM

A. Administrative Organization

The organization chart of the team depends on the administrative and management functions implemented: operation, training, safety, technical and regulatory.

Drone team Manager

All teams have a program manager or manager in charge. This manager is sometimes a drone pilot, but it is not mandatory. More importantly, he or she has influence over the decision makers of the organization. This Manager is most of the time also the drone operations manager.

Operation Manager / Response planning Manager / Director of drone operations

This person is responsible for drone operations and standard operating procedures. It defines how operations should be performed. He can also participate in flight planning.

Training Manager

Most drone teams have an internal instruction and / or training service. The training Manager plans initial and continuing training with a pool of drone trainers.

Safety Manager / Aerial Safety Officer

A safety manager is required to advise the drone Manager on air accident prevention policy (implementation of a flight safety management system), prevention of human factors and to conduct accident investigations.

Technical Manager

A technical manager can be useful to ensure the functions of technology watch, purchase, maintenance of drone systems and accessories. The obsolescence of drones and technological innovation being so rapid, a person or a small technical team is needed to monitor market developments.

Legislation Manager

A specialist in drone law and regulation is also very useful in the team. The latter is increasingly important now that national and international rules on aerial drones are developing and changing relatively regularly. And the emergency services often have a special status vis-à-vis the flight exemption. In addition, the subjects of respect for private life and personal data (example: the RGPD in Europe) are very sensitive. A person dedicated to regulatory watch and the organization of data management is a way for a public security service not to expose itself legally and to reassure the public.

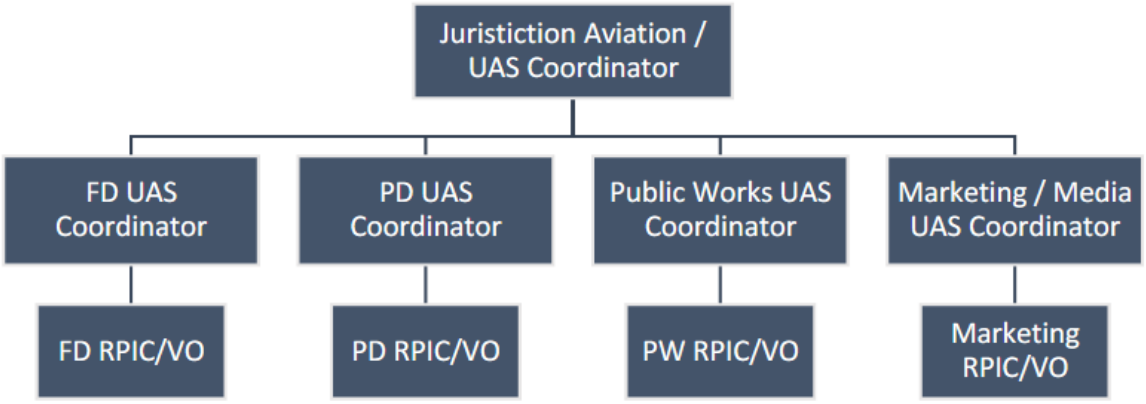
Lead Pilot or Chief Pilot

The chief pilot is often an experienced and seasoned drone pilot. He leads the team of pilots. He is responsible for the following tasks:

- Ensure the drone is operated to the highest level of safety and that all crew members maintain professional standards at all time.
- Supervise the screening, selecting and monitoring of drone pilot candidates.
- Providing feedback to pilots & crew
- Pilot scheduling for planned flights
- Work in coordination with the training Manager and monitor status of crewmember qualifications.

Regional Drone Coordinator

In some countries, for example in the USA, there is a special function: the Regional Drone coordinator. He oversees all unmanned aircraft public safety program operations for the Regional Aviation Jurisdiction. They may also coordinate training for commercial unmanned aircraft operations within other departments.



The responsibilities of this person are:

- Ensure flight crews are compliant with all Civil Aviation requirements
- Maintain a current list of certified crew members
- Establish and develop departmental drone Coordinators within the Jurisdiction
- Monitor and record the condition, maintenance, and flight records of all drone and associated equipment
- Perform monthly Civil Aviation reports and record management duties
- Ensure monthly flight skills and classroom training is completed in all departments

A good idea: the pooling

An interesting good practice, observed in the United Kingdom, consists in pooling human and material resources between several departments (for example , police and firefighters) to share and reduce costs (equipment and crew).

The drone crew can be mixed (1 policeman and 1 firefighter) but for police operations, it is indeed a policeman in charge of the operation, and similarly a firefighter in command of a fire operation.

B. Operational organization

Human resources

Most teams operate with at least a crew of 2 people, made up of a pilot and an observer / team leader. If we consider the many tasks to be performed to work in safety (piloting, aviation safety, land safety, mission management, image analysis, radio and incident commander management), a crew of 2 people is strongly recommended in order to 'avoid accidents, unfortunately very often due to the human factor.

DRONE Pilot or RPIC, Remote Pilot in Command

The pilot is the crew member who has final authority and responsibility for the operation and safety of the flight. He holds the appropriate pilot training and type rate. The pilot is also trained to collect imagery (electro-optical or thermal images / videos) and to activate a payload to perform an action (search for a victim, bring lighting, designate a point, drop an object, broadcast an audio message). It is capable of performing both visual and hidden flights. He is responsible for his equipment; he has the authority and responsibility for its flight and related safety.

VO, Visual Observer

The Visual Observer assists the pilot to locate and avoid other air traffic or objects aloft or on the ground. On the other hand, the observer may have some pilot training or at least is familiar with drone technology. It must obviously have a means of radio communication to be coordinated with the pilot.

Drone Team Leader

The drone Team Leader represents his organization and is responsible for the drone equipment and crew while on scene at an incident. In some country, this position may also be referred to as the Air Boss. The drone Team Leader maintains an appropriate span of control for the team and provides a single point of contact for drone operations / data processing to incident leadership in the field. Depending on the country, agencies and drone, the drone Team Leader's tactical responsibilities may include, but are not limited to the following:

- Receive mission assignments and forward those assignments to the pilot
- Manage take-off / landing area (TOLA)
- Manage airspace separation assurance standards between aircraft, to include both manned and unmanned operations
- Manage ground safety surveillance
- Operate the payload (thermal / zoom camera, headphones, lights)
- Liaises with the incident commander (communication & information)

Take-Off / Landing Area (TOLA) Manager

The TOLA Manager is a required position anytime there are two or more unmanned aircraft flying from the same takeoff / landing area. The TOLA Manager oversees the takeoff / landing area, coordinates altitude separation between aircraft, and manages air traffic takeoff and landing operations. The TOLA Manager receives mission assignments and assigns those missions to the appropriate drone teams.

Data Technician or Specialist

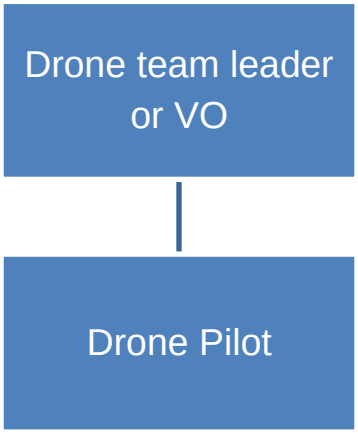
The Data Specialist or Technician works as a team member with the Pilot to generate data required for tactical or strategic level planning, assessment, or decision-making. The Data Specialist is mostly required when the mission relates to large scale perimeter calculation and / or complex and long-term operations that generate a large volume of data. This person may be a computer scientist, a GIS specialist or a pilot trained in this technology. The Data Technician specializes in the following:

- Performs preflight and post-flight safety and security checks of onboard data gathering and streaming equipment.
- Ensures that the flow of data, data recording and streaming equipment is operational preflight, during flight, and post-flight to achieve the mission objectives.
- Converts data into either a pre-processed dataset or precision product such as geo-referenced maps, orthophotos, digital elevation models, or 3D terrain models.

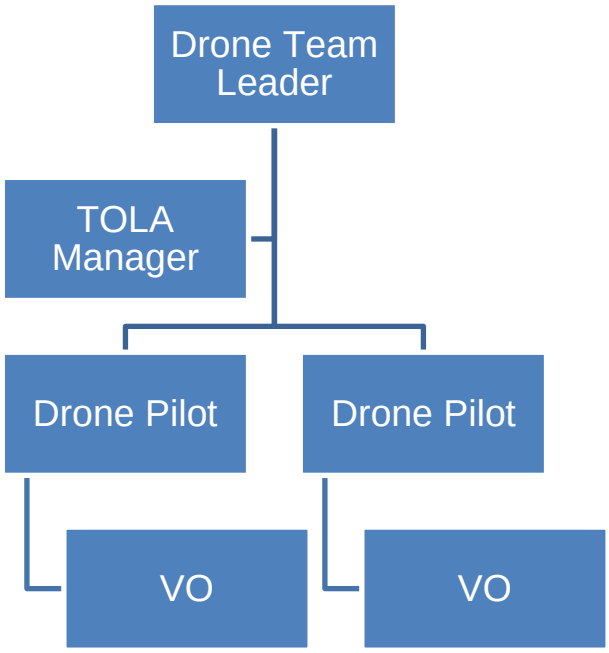
Team Organization

Several organizations exist.

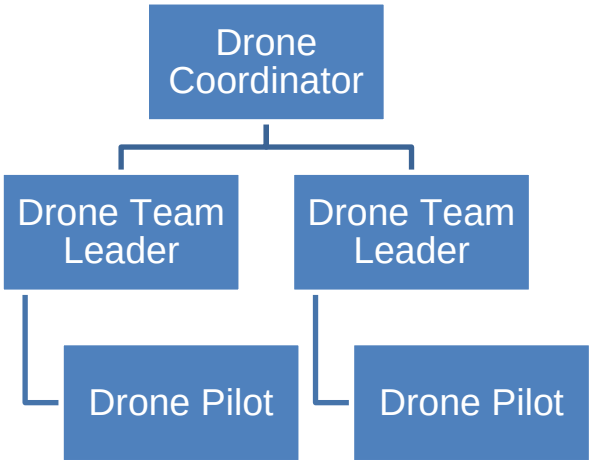
Option 1 is a crew consisting of at least 2 people, a drone pilot and a team leader or a visual observer (VO)



The option 2 consists of at least one drone pilot, one visual observer, one drone Team Leader , and possibly a Data Specialist or TOLA Manager.



In the case of a multi-drone operation, a drone technical advisor coordinates two teams and acts as TOLA Manager. VO and Data Technician are optional.



Whatever the operational organization of the team, the essential functions to carry out an aerial drone operation do not change and must be carried out by the team. Everything is a question of distribution of tasks:

- Piloting the drone
- Aerial safety (visual)
- Land safety (visual)
- Monitoring of aeronautical frequencies
- Mission management
- Monitoring of incident frequency commander
- Analysis and use of data
- Management of equipment and batteries

This list being long, it is for this reason that it is not recommended to pilot a drone alone on an incident. The accident risk factor increases dramatically.

Surveys by our national working groups have shown that drone teams have an average of 8 pilots to ensure 24/7 permanence. Most of the crews come from a public security service or agency. Yet sometimes, when these agencies are small, we can notice that drone crews are external and private providers but they do not have the culture of public security operations.

Material resources

After having surveyed the participants of the different working groups, it turns out that most teams have an average of 4 drones in service, mostly quad-rotors, either several small drones of less than 2kg/4lb, or a "heavy" drone of more than 2kg/4lb.

Team communication is ensured by the radio network usually used by the rescue organization. However, some teams also have aeronautical radio equipment to ensure monitoring and/or coordination.

Not all drone teams always wear a protective helmet. The pilots who do not wear them justify themselves by explaining that the drone does not fly over them. Pilots who wear helmets justify themselves by explaining that it is difficult to ask ground rescue teams (near drones) to wear their helmets if they themselves are not. Only one certainty remains, the risk of falling (even low) exists near the pilots during take-off / landing, but also near the ground teams.

That's why we recommend everyone to wear helmets, because safety is everyone's concern.

Drone vehicle

In order to deploy the drone team, several options are possible. But before describing them, we must understand the operational and logistical needs of a drone team. The needs are mainly oriented on logistical support for transport but also energy management: batteries. It should be understood that the ability to recharge your batteries in the field is critical. Moreover to maintain them in their optimum use, you must avoid cold and heat. In addition, there is also a strong need for communication, transmission of the information collected and therefore screens. A large screen will provide undeniable comfort for sharing a tactical situation.

Several solutions are possible to deploy a drone team:

- Either by a conventional emergency vehicle (the drone equipment is placed in the trunk), with the option of positioning a large television screen is installed in the trunk with a power supply supplied by an electrical transformer connected to the vehicle battery), this configuration allows the team, the drone and the accessories to be transported, and in addition to sharing the visualization of the pilot's screen. Not to mention that the electric transformer can also be used to recharge the batteries.

Photo courtesy of SDIS 77

- Or by a light emergency vehicle (car) only dedicated to the drone team with a more developed and definitive layout.

  The layout includes:
  - a central screen in the trunk for live viewing for the incident control
  - of a power supply system for the screen and the batteries
  - of a transmission system (several radios)

- Or by a vehicle specific and dedicated to the drone team, an even more advanced configuration that requires a van or a small van.

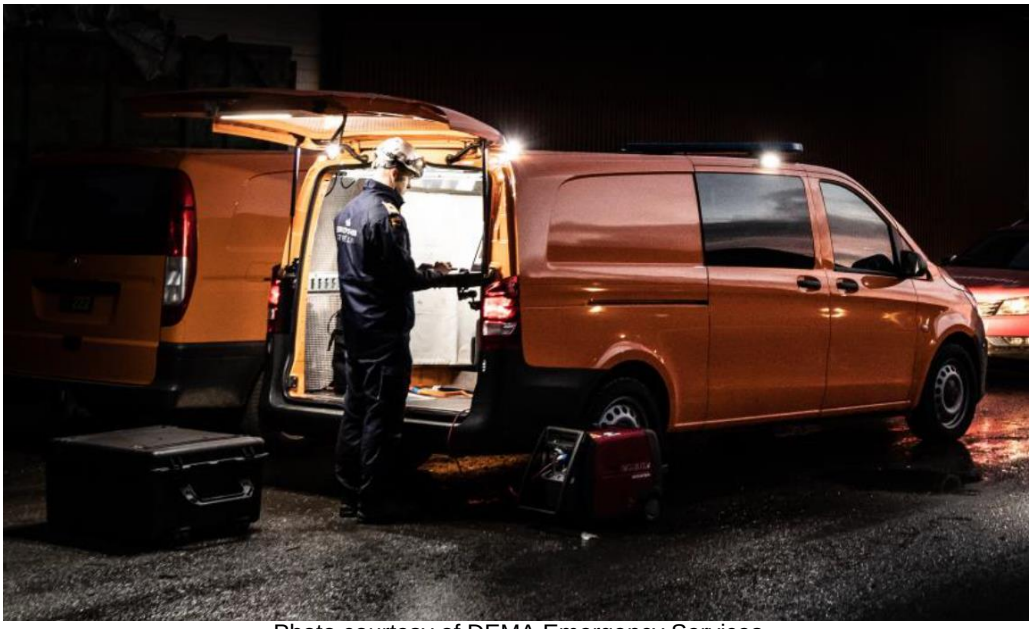


Photo courtesy of DEMA Emergency Services

This last configuration makes it possible to transport several drones and heavy equipment. Be careful, however, not to confuse it with a classic command post, it is only a van allowing to use the images and provide logistical support for the drone team.

These vans are equipped with:

- one or more drones (fixed or rotary wing)
- one or more screens for live viewing (for the incident order outside or inside to work on the photos)
- an electrical system for charging numerous batteries (either with an electrical transformer or directly on high voltage batteries)
- A portable electric generator
- of an air conditioning system (for the batteries)
- of a cellular transmission system or satellite
- of a possible Wi-Fi access point
- of an office equipped with computers
- and a color printer

Photo Courtesy of MEKS Emergency Drones

It is not surprising that most vehicles are 4x4 powered; this greatly improves the range of the drone team even on difficult terrain.

Tactical backpack

In addition, in rough terrain situations that involve an approach march, the tactical backpack solution, comprising a small compact drone and the minimum of essential equipment, can allow the drone team to keep rapid deployment and mobility.

Photo courtesies of SDIS 78

C. Safety management

Safety is a major and essential subject for a drone team. A heritage of aviation culture, air crashes must be avoided at all costs. And if it is inevitable, the team's safety manager must implement an investigation procedure, an investigation and a safety analysis in order to collect the data and understand the causes of the accident. And this in order to avoid the renewal of conditions favorable to an accident.

Flying a drone (weighing several kg or lb) in an emergency, stressful situation and spontaneously requires a culture and procedures related to safety. It needs a framework allowing the mitigation and control of risks which should aim at reducing the probability of accidents.

The risk assessment must generate a series of preventive security measures. These measurements are broken down into 3 phases: before, during and after each flight.

BEFORE FLIGHT

Training
Training hard makes work easier but above all allows you to maintain safety rigor. In this spirit, the drone team must always choose to reproduce realistic missions in controlled environments and simulators to maintain its skills.
Simulators are a great way to fly a drone when the weather does not allow it or to implement emergency procedures such as:

- Engine failure;
- Loss of camera connection;
- Deterioration of weather conditions (wind, rain, fog, others);
- Electromagnetic interference

Topographic and aerial analysis

The objectives of this evaluation are to:

- analyze the feasibility of the aerial operation
- know the environment in which the drone team will operate

<u>This initial analysis consists of the map study of the following elements:</u>

- Size and position of the incident zone
- Planimetry, the studies of:
  - Roads, railways, waterways, lakes, rivers
  - Human activities (Camping, concerts, hikers, etc.)
  - Vegetation cover (fields, woods, brushwood)
  - Sensitive points (Schools, hospitals, shopping centers, military bases,…)
- Leveling (slope, curves, uneven ground, crest and thalwegs lines).
- Obstacles (High voltage power lines, transmission pylons, various antennas, radio relays, cranes, wind turbines and suspended cables)
- Housing and architecture

- Areas and airspace (all areas and airspaces concerned, and also the CTR air protocol to be activated)

Meteorological conditions analysis

The meteorological conditions are to be studied via websites or meteorological forecasting applications which can provide information on METAR and TAF bulletins.

- Calendar

  It is about paying attention to the date and time. The date makes it possible to put a context either on the probable meteorological conditions (winters, etc.) but also on the day / night character that impacts the mission.
  The traffic conditions for transit are also different depending on the time of day and day.

- Temperature

  The temperature makes it possible to anticipate a necessary heating of the batteries (cold temperatures) but also special conditions of use of the thermal camera (temperature contrast). Scorching conditions also impact the batteries but also the mission in terms of aerology (hot updraft over fields).

- Rainfall

  Obviously, rainy conditions prevent all aerial operations in the absence of a sealed aircraft.
  What to do in case of showers during the flight must be implemented beforehand.

- Wind

  The force of the wind occupies an important place in the zone study since it can cause the cancellation of the mission if it exceeds the limitations of the aircraft. The wind direction governs the choice of the location of the TOLA.

- Forecasts

  If studying weather conditions is important at the time of the alert. It is also essential to extend this study to a forecast of + 4h at least.
  A study of the meteorological forecasts must be made on a regular basis on long-term operations.

- Magnetic condition

  It is imperative to check the magnetic conditions before each deployment.
  Magnetic storms create a high risk of "fly-away" and disturbances during flight.

- Special conditions

  It is necessary to study the area with the typology of the incident as a prism.
  A powerful forest fire can generate a large plume of smoke and disturbing wind currents. The presence of gaseous chemicals, for example, requires a different aerial approach and special security measures.

Risk analysis

The objective is to make a reconnaissance on arrival at the incident area to analyze all the risks present which may influence the air operation.

Terrestrial risks

Terrestrial risks are multiple and depend on several factors:

- Natural and artificial
- Obstacles
- Magnetic disturbances (metallic mass)
- Transport flows

Air risks

The air risk concerns all the elements that may contribute to an air accident:

- Manned aircraft (civil and military)
- Aircraft unmanned (civilian and military)
- Paratroopers, paragliders
- Birds

Moreover, all those involved in the incident area (firefighter, medical, police) should wear a protective helmet while flying over the drone. It is the responsibility of the incident order.

Human risks

The human risk has 2 components:

- External disturbance

  The drone team must be vigilant in order to assess the risk of human disturbance during the aerial operation. This could be the entry of an outside person (public) into the incident area or into the TOLA during the flight.

- Human factor of the drone pilot

  The drone pilot must be fully in possession of his means. He should not:
  - Have consumed alcohol during the 8preceding the flight
  - Being ill, under specific drug treatment
  - Being in a state of stress whatever it is
  - Lack of sleep hours(at least 6 hours of sleep)

  It is up to everyone to be responsible for their ability to fly the aircraft. Within the drone team, the team leader or the visual observer must carry out a cross-check.

  There is a "head-up" tunnel effect impacting the drone pilot. During flight, it is focused on the spatialization of the actions performed on the flight controls. His attention is waning and he is no longer aware of his immediate surroundings. The team leader or the visual observer must therefore protect him from any external solicitation or interaction.

Technical risks

If the drone is not properly maintained or checked, there may be a risk of crash, fall or accident in general.

To control this technical risk, most drone teams have set up a pre-flight checklist to check the drone and the associated systems. This is a list of technical points to check (batteries, RTH, number of satellites received, settings, payload test, etc.).

In order to provide a framework for the pre-flight briefing of the drone team, some teams use the acronym **AWARE**:

- Aircraft must have regular maintenance and checklists to always be at its best performance so the drone responds to the pilot's commands as expected.
- Weather is one factor that can externally affect the flight and should always be taken into account when preparing a flight.
- Airfield information gives the drone team the information and radio frequency to use for aerial coordination
- Routes must be planned to predict possible obstacles and Emergency Landing Area (ELA) if needed.
- Extra refers to everything that isn't in the previous points, but it's important to be referred to in the briefing, such as additional safety measures, other drones or aerial vehicles in the area.

IN FLIGHT

After takeoff, the drone team must follow the procedures and stay focused on the mission and safety. To this end, a flight safety perimeter must be defined to prevent the population from interfering with or distracting the drone team, this flight perimeter may correspond to the security perimeter of the incident.

Weather updates should be checked regularly and changes in the airspace (other air vehicles or birds) should not be overlooked at any time as they could change on an occasion and without warning.

Pilots should always be aware of all emergency procedures to be implemented in the event of distress or unforeseeable events.

Knowing how to react to each type of event can help prevent injury to people and reduce damage to equipment. This is only possible if different types of procedures are written and known.

There are some important key points that need to be taken into account on board to minimize the risk of an accident, which the team should tackle:

- Assess the height and position of the highest obstacle;
- Define a minimum working height;
- Give priority to visual flight (VLOS) as much as possible;
- Pay attention to alert messages (battery level, warnings, interference);
- Be aware of the fatigue of team members, especially pilots.

POST FLIGHT

After landing, the team should focus on the procedures that allow the drone to be preserved (for a new flight that could take place a few minutes after landing or for storage) such as:

- Replacing and charging the battery;
- Check for any signs of damage or deterioration;
- Recover all data relating to the theft (images, videos);
- Write a detailed flight report
- Perform preventive maintenance if necessary.

To preserve the pilot, in the same way, the pilot can be changed if possible.

To conclude this chapter on safety, the most important points to remember are:

- ✔ Maintain strong communication within the team, with the incident commander and the air traffic control services and manned aircraft pilots
- ✔ Minimize exposure to risks to each phase
- ✔ Try to anticipate everything to avoid the surprise of amazement

5. OPERATIONAL CAPABILITIES

Everyone has heard the term "drone". It is increasingly a popular way of referring to the small helicopter-like devices that are flown by millions of people around the world. However, there are a host of other terms used to describe them.

Drone? UAS? UAV? RPAS? UA?

A UAV or drone is defined as "a motorized aerial vehicle which does not carry a human operator, which uses aerodynamic forces to lift the vehicle, which can fly autonomously or be remotely piloted, and which can carry a payload.

“Unmanned Aircraft” means any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board;

This definition includes all types of aircraft without a pilot on board, including radio-controlled flying models (powered fixed wing, helicopters, gliders) whether they have an on-board camera or not.

The EU regulations use the term UAS, unmanned aircraft system, to refer to a drone, its system and all the other equipment used to control and operate it, such as the command unit, the possible catapult to launch it and others. RPAS (Remotely Piloted Aircraft Systems) is a subcategory of UAS, which includes both RPAS and fully autonomous UAS. Fully autonomous UAS fly completely by themselves without the need for any pilot intervention.

This UAS terminology is used by the Federal Aviation Administration (FAA - United States), the European Aviation Safety Agency (EASA) and the United Kingdom Civil Aviation Authority (CAA).

The RPAS (Remotely Piloted Aircraft System) designation is used by international civil aviation agencies such as Eurocontrol, the European Aviation Safety Agency (EASA), the International Civil Aviation Organization (ICAO), the Authority Civil Aviation Security Authority (CASA - Australia), the Civil Aviation Authority (CAA - New Zealand)

The drone, the UAV, this aerial vehicle is made up of:

- A frame that carries the load useful, the engine and onboard systems;
- A lift which is generally provided by a fixed or rotary wing;
- An engine (electric motors, rotors);
- Propellers, they produce thrust;
- Batteries.

<u>Fixed-wing systems</u>

The term "fixed-wing aircraft" is a term used to define aircraft that use fixed and static wings combined with forward airspeed to generate lift.

Multirotor systems

The multirotor system is a term used to define aircraft which use rotating wings to generate lift. A popular example of a rotorcraft is the traditional helicopter. The rotorcraft can have one or more rotors. When we add the following elements to a UAV, we speak of drone, UAS or RPAS system:

- Electronic speed controllers (ESC), they manage the speed, direction and rotation of the motors ;
- A payload often placed below the structure for data acquisition, by electro-optical or thermal sensors capable of reproducing images.
- A flight control system (ground station or cockpit) by telemetry

When the drone is equipped with a specific payload, a new range of missions is then opened by multiplying the activities and therefore the capacities. Here are some of those abilities described under the spectrum of rescue and firefighting missions.

A. ELECTRO-OPTICAL CAPACITY

Nowadays, the vast majority of drones are equipped with a camera, electro-optical sensor.

Camera Resolution:

The camera resolution is the amount of pixels that the sensor will map. The approximate range of the UAV camera today varies between 2 and 50 Mpx. A high resolution camera provides a greater ground sampling distance (GSD) for an equal sized camera sensor compared to a lower resolution.

The GSD is the actual size of a pixel in your photos that sets a physical limit on the accuracy of your shot. If your GSD is 5cm, the product map will be accurate up to 5cm/2inch.
GSD is measured in cm / pixel and usually ranges from 1 to 5 for aerial photos.

The ground sampling distance is defined by several variables:

- Altitude of the image capture
- Aperture
- Size of the camera sensor Camera
- resolution
- Focal length of the camera lens

However, higher camera resolutions don't necessarily mean an absolute advantage. High resolution also results in much larger storage and therefore longer transfers times.

Sensor size

The sensors are available in different standard sizes:

- 2/3 ”,
- 1”,
- Micro 4/3 rds,
- APS-C,
- Full frame.

Larger sensors will have better ability to pick up light at the same resolutions, while smaller sensors will require more exposure time to achieve the same result.

Camera aperture

The aperture defines the light exposure of the sensor. If the aperture value, marked with f, is fixed, it directly affects images captured by a camera.
Drone cameras often have a low fixed aperture value (example: f / 2) which places all objects within a few feet of the camera in an infinite focus area.

Focal length

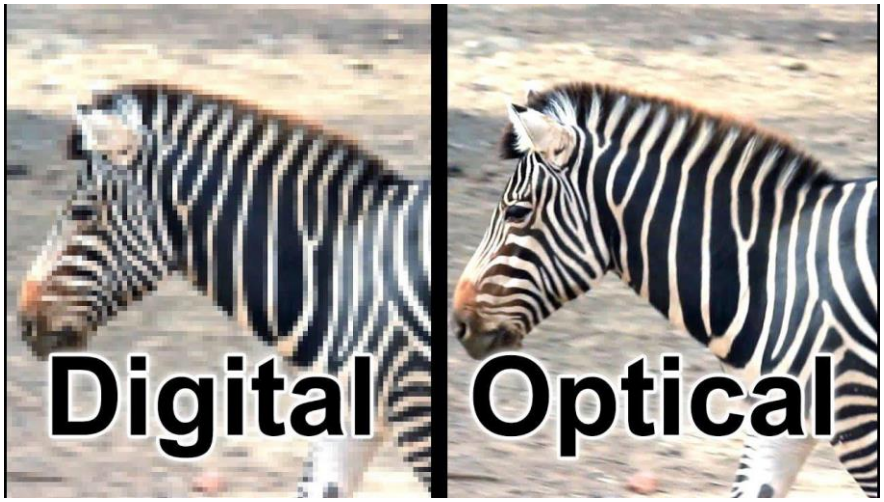
The focal length is a combination of the size of the sensor, an effective distance from the mirrors inside the lens and the curvature of the glass.

Drone cameras offer various lens options that can cover anything between 10mm to 1200mm in effective focal length. Long focal lengths typically associated with lower resolution and used for visual inspection purposes are not suitable for a high resolution inspection need.

B. ZOOM CAPACITY

Sometimes, a drone cannot approach a dangerous or difficult to reach area. In both cases, the zoom capability appears to be a suitable solution. There are two zoom technologies: optical zoom and digital zoom.

- **Optical zoom:** this zoom is a true zoom lens, like the zoom lens you'd use on a film camera. They produce much better-quality images



- **Digital zoom:** it consists in some in-camera image processing. When you use a digital zoom, the camera enlarges the image area at the center of the frame and trims away the outside edges of the picture. The result is the same as when you open an image in your photo-editing program, crop away the edges of the picture, and then enlarge the remaining portion of the photo.

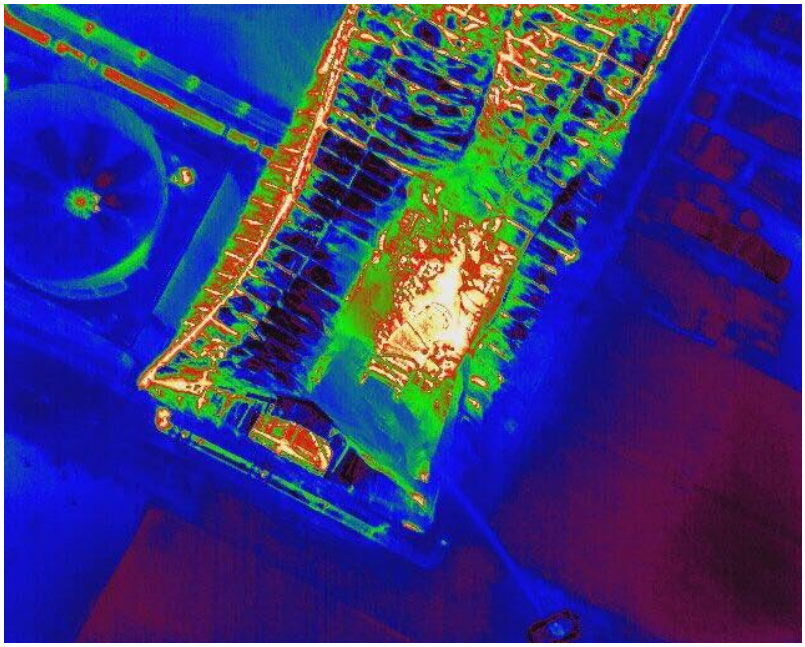
C. THERMAL CAPACITY

One of the most important capabilities is the ability to obtain thermal imageries.
Thermal images are a great help when finding people, animals, or hot spots, as most of the time the body is warmer than the surroundings.

Thermal imaging cameras are electronic devices designed to detect thermal energy.

The key element of a thermal camera is a heat sensor attached to a special type of lens, which is then adapted to work with standard image capture technologies.

Visible light is only a small part of the electromagnetic spectrum, and the only part that we can actually see. When pointed at an object or area, a thermal detection camera's sensor allows the user to view the otherwise invisible infrared spectrum that exists at wavelengths between visible light and micro-waves.



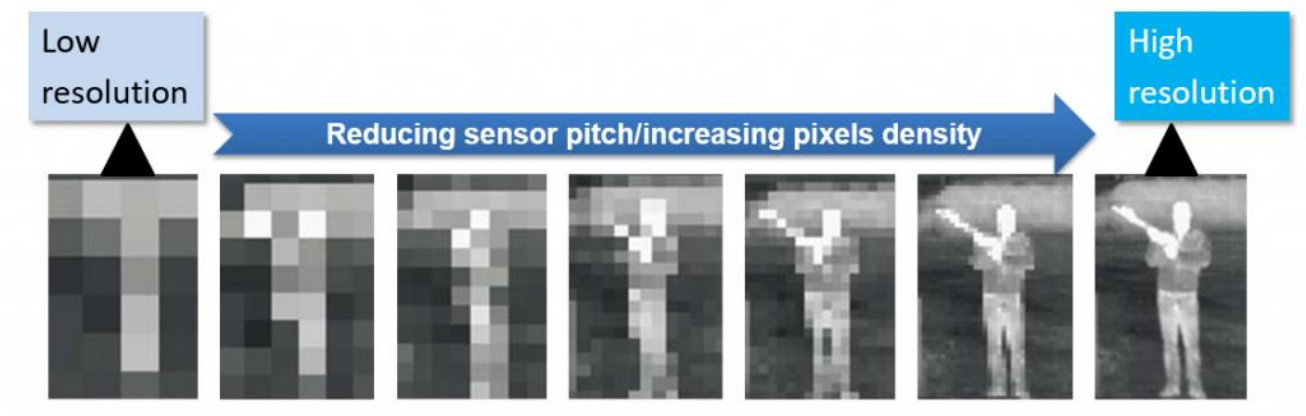
On a color thermographic display, warmer components or regions will appear as reds, oranges, and yellows, while cooler portions will generally be shown as violets and blues (green usually indicates areas that are approximately at room temperature).

Because they measure infrared radiation, not visible light, thermal imaging cameras are also useful for identifying heat sources in very dark environments such as nighttime conditions. Thermal imaging cameras tend to perform best at night, but that has nothing to do with the state of the surrounding environment being bright or dark. This is because the ambient temperature is very often much lower at night than during the sunny hours of the day, thermal imaging sensors are able to display hot areas at higher contrast.

Imager format
When choosing a camera, imager format is an important specification to consider.
Imager format is basically the number of pixels on the detector array. To determine a camera's imager format, typically a standard two-dimensional matrix is used.

High resolution thermal cameras often have a 640 × 480 detector, which delivers 307,200 pixels; compare that to 76,800 in a thermal imager with a 320 × 240 detector.

Standard formats are 160 × 120 (19,600 pixels), 384 × 288 (110,592 pixels), 640 × 480 (307,200 pixels). But to do search & rescue missions, a 160x120 format will force you to fly to a maximum height of 30 meters (100 ft) if you want to be able to discern a victim. The best format for SAR is at least 640 × 480; it will allow you to fly above 30m / 100ft.



But a 160x120 format is enough to visualize and locate a hot spot.
It must be noted that a bigger imager format doesn't improve the visibility of an object (object is not any larger, but the same size), it determines the scene size or range. Typically, the bigger the format, the bigger usable range of the camera you will have.

Frame rate

One more important characteristic is related to the image processing capabilities of a camera. Frame rate is the speed at which an imager updates its output information to be displayed on a screen. A 9 Hz camera does so 9 times per second, and a 60 Hz camera - 60 times per second.

What is the difference between infrared camera and thermal camera?

Active IR systems use short wavelength infrared light to illuminate an area of interest. Some of the infrared energy is reflected back to a camera and interpreted to generate an image.

Thermal imaging systems use mid- or long wavelength IR energy. Thermal imagers are passive and only sense differences in heat.

D. LIVE STREAMING VIDEO CAPABILITY

Drone live streaming systems are one of the most interesting tools to use as they allow a real time view of the onboard cameras to be shared. This makes it possible, for example, to share the incident and order a live video feed of the crisis situation and the actions in progress seen from the sky. Thus situational awareness is very strong and accelerates decision-making.

Some key points of streaming are:

- Image quality;
- The refresh rate of the image;
- Transmission power;
- Video recording capacity and storage;
- A web video consultation platform accessible from computers, tablets and smartphones
- Securing the access platform (URL link, password)

Attention, the distribution and storage of streaming video must comply with the national laws of your country at respect for privacy and personal data. If a face, a license plate, a personal identification data is disseminated and stored; you must have a policy and an organization for the handling of the data just like with images and videos.

A risk remains, however, by sharing the streaming stream at the center of operations. Stakeholders could fear that higher hierarchical levels interfere in their field of action. A high-level decision-maker might, depending on the raw images received, be tempted to directly command the tactical echelons or influence their decision without being on site.
To remedy this problem, programming a slight delay in the broadcasting of the video stream to the operations center can allow the incident commander to retain the exclusivity of the field command.

E. LIGHTING CAPACITY

It was in 2018 that a new technological brick appeared on a drone, a lighting technology.
A priori however simple idea, but the addition of this technical capacity it was necessary to think about it.

The challenge lies above all in the integration of spotlights powerful enough to illuminate at a working height but without consuming too much energy for the drone's battery.

The lighting capability improves the nighttime operating conditions, adds working comfort and safety.

Depending on the configuration of the drone, we can have:

- Either a lighting payload supplied directly by the drone's battery, the power is sufficient to illuminate at a height of 30m / 100ft or even more but there is less flight autonomy.

- Either a light and autonomous system of auxiliary lighting fixed on the structure of the drone, the power is lower but sufficient for indoor lighting and there is no impact on the autonomy of the drone

F. CAPACITY OF EMPORT

The maximum weight that a remotely piloted aircraft can carry is expressed under the term "payload".

The characteristics and functions of drones can vary greatly from model to model and directly impact the maximum weight they are able to lift and carry.
These drones are able to carry impressive loads, while maintaining sufficient autonomy to carry out their missions, thanks to the capacity of the Lithium-Polymer battery, as well as to the power of their motorization and the number of these engines, or rotors. For example, a “heavy” drone can take off and fly carrying a payload of 6 kg, while its own weight is only 10 kg, for a flight time of up to 38 minutes.
We are witnessing a real race to record payloads transportable by drone, but we must always put these figures, which can reach more than 60 kg, because most often these flights only last a few seconds or minutes and are carried out only at very low altitude and on sight.

G. SOUND CAPACITY

Since 2018, some drones have been equipped with speakers making it possible to broadcast sounds or messages from the sky. This establishes a first step in the intercommunication which remains for the moment one way since a microphone on a drone is not possible today.

This capacity depends on the strength of the sound signal emitted in decibels. A sound wave theoretically decreases by 6 dB by doubling the distance. You must therefore choose the power of your speaker to be heard.
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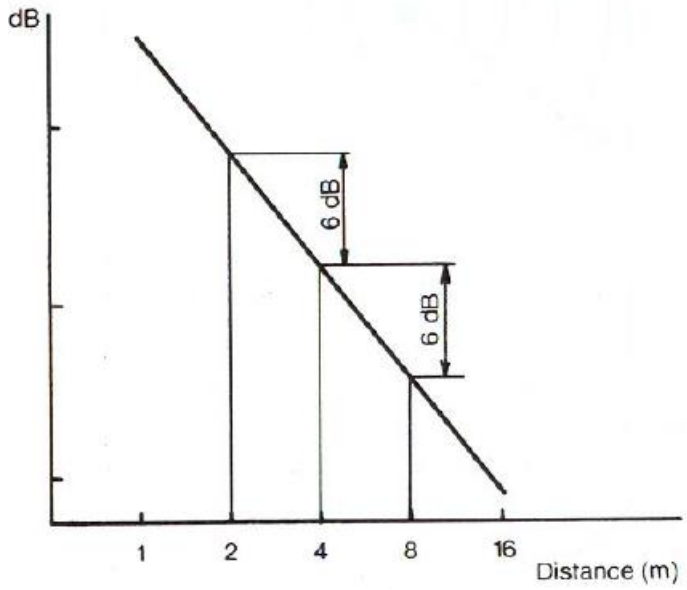


6. BASIC TECHNIQUES

Assuming that fire and rescue services as well as SAR associations often face the same situations, the same types of mission, we can observe that the aerial techniques used are in fact quite similar. It has been observed that several relief organizations are at the origin of the same technique, which is why we have not mentioned the origin of these basic techniques considering that paternity is often shared. Here is the non-exhaustive description of good basic practices and techniques.

CATEGORY	ASSIGNMENT	TECHNICAL
INFORMATION	**initial Intelligence**	Spiral technique
		360 ° rotating technique
		Indoor recognition technique
		Mapping technique
		Geometric evaluation technique
		Live video streaming technique
	Continuous Intelligence	Search for danger technique
		Search for sensitive points technique
		Surveillance technique
		Evaluating Action technique
ACTIONS	**Victim search**	Comb technique
		Light search technique
	Alert	Sound diffusion technique
	Lighting	Lighting technique
	Guidance	Action guidance technique
		Shepherd technique
	Release	Dropping object technique
	Designation	Point Designation technique
	Safety watch	Safety Escort technique

A. AIR INTELLIGENCE COLLECTION

1. SPIRAL TECHNIQUE

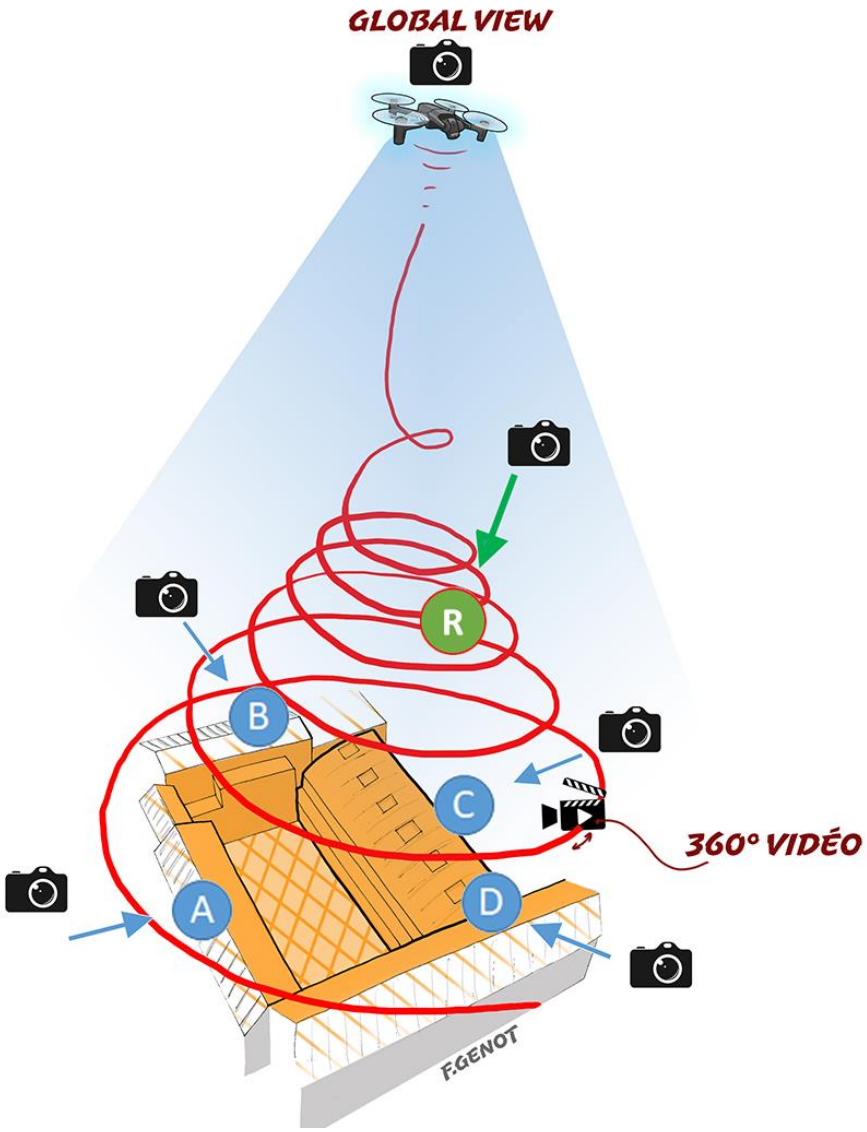
When a remotely piloted aircraft is deployed to obtain image intelligence on an initial situation, the first of the air evolutions is that which resembles an orbital flight. A circular movement centered on the point of interest in order to obtain all possible angles of view to collect as much information as possible on the current situation.

This technique is called **the spiral**, it breaks down as follows:

1- A circular evolution around the building to collect 4 photos (ABCD facades)
2- A circular evolution to capture a short video of the 4 facades of the building
3- A vertical shift centered to capture a photo of the roof (R) and the tactical situation as a whole

Each snapshot captured with a visible camera can be duplicated with a thermal camera depending on the needs of the incident commander.

The video should be less than a minute if possible for two reasons: a short video captures more attention than a long one and to minimize the amount of data storage.



2. 360 ° ROTATING TECHNIQUE

In an initial information gathering process, interest can be focused on the peripheral environment of the disaster.

In order to capture this immediate environment, the aircraft can be used to perform the 360¨rotating technique:

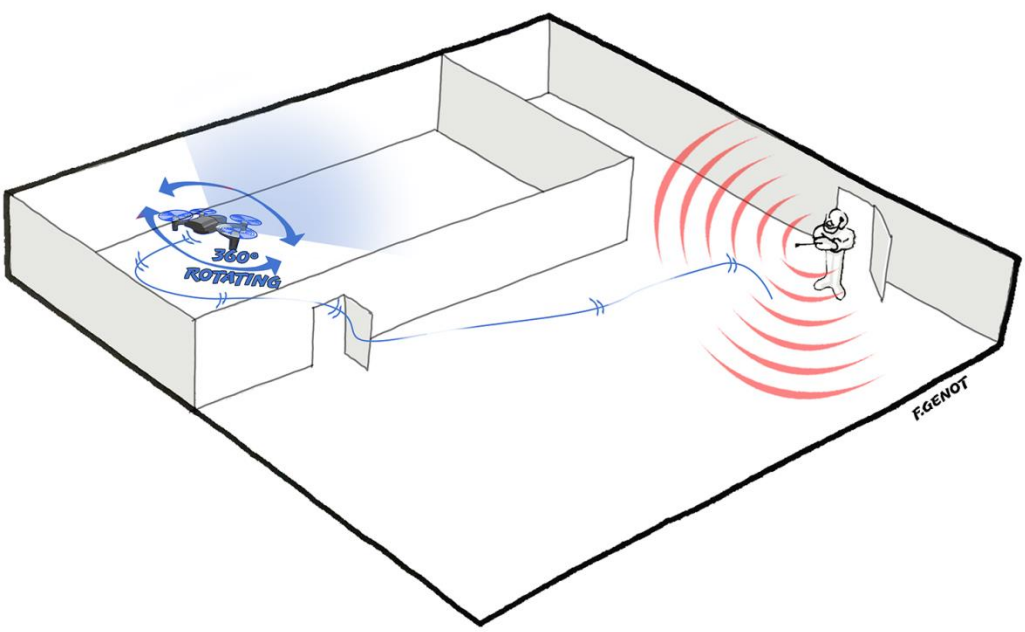
1- Frame the field of view in height
2- Make a 360 ° rotation by recording a short video

The If possible, video should be less than 30 seconds for two reasons: a short video captures more attention than a long one and to minimize the amount of data storage.

3. INDOOR RECONNAISSANCE TECHNIQUE

This involves carrying out an indoor reconnaissance in an inaccessible or dangerous building (exclusion zone, risk of collapse, etc.). This type of evolution in a closed environment is very difficult to achieve due to the fact that the drone is no longer stabilized by a GPS signal and that the obstacles are numerous.

The evolution must take place as slowly as possible at a reasonable distance from the ground. It is necessary to separate the movement sequences (forward movement, rotation, translation, etc.). The same progression technique can be applied as the firefighter attack teams (follow the wall to the right or to the left).



To recognize a room, the aircraft:

1- is placed in the middle of the room
2- performs a 360 ° rotating to sweep the whole part
3- can approach a point of interest identified during the 360 °rotating

The crew can perform a drawing of the path of the drone during the interior evolution to produce a plan of the building and points of interest for the incident commander.

The estimation of distances is altered, making the risk of collision much greater. Be careful, the absence of a GPS signal can disturb the aircraft, the RTH characteristics must be set for a landing or a hovering flight.
The use of a light spot requires a depth adjustment, because the light has a strong reverberation on the dust particles.

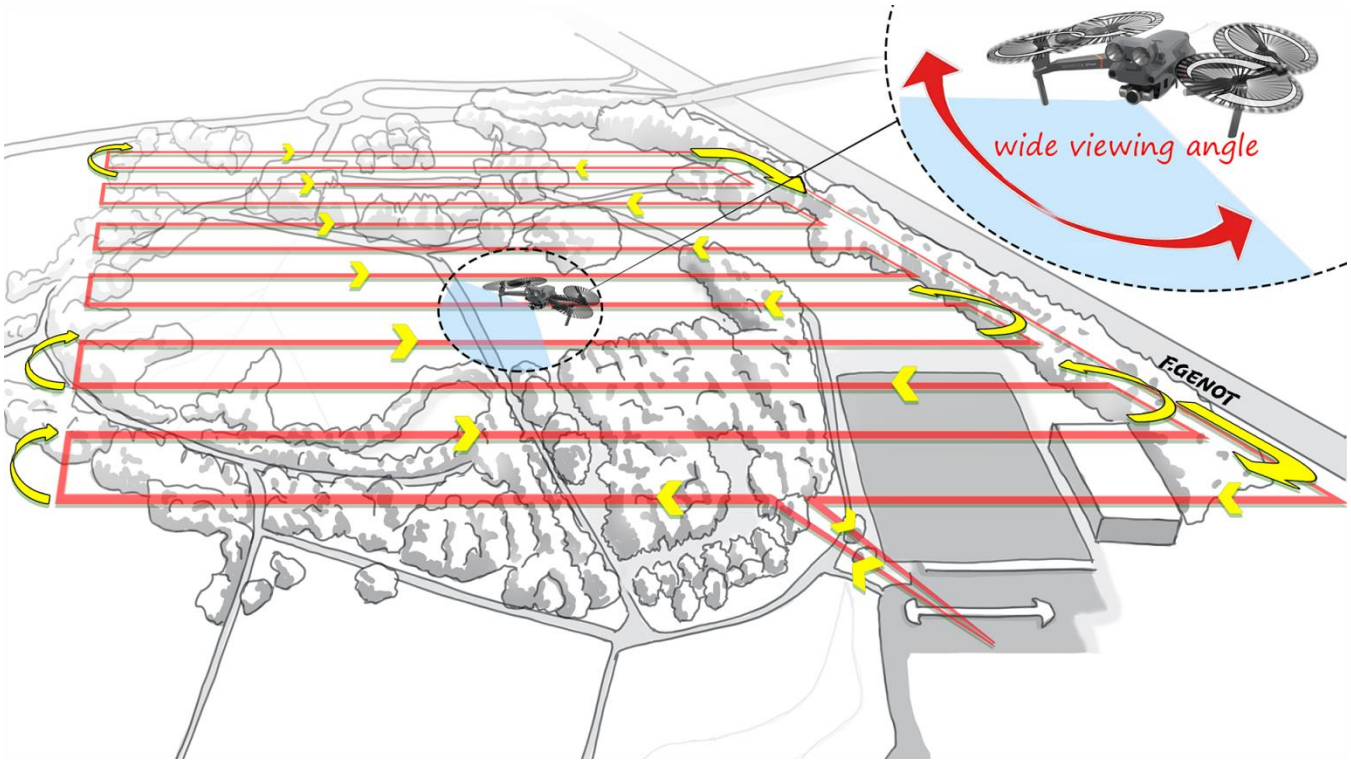
The TOLA is not necessary if the flight begins indoors. If the flight begins outdoors, TOLA is required and an outdoor / indoor transition is performed with care and flight mode monitoring (loss of GPS).
In the case of reconnaissance inside a building, a drone can be used instead of personnel in order to limit exposure to the risk.

4. MAPPING TECHNIQUE

The production of a disaster map by photogrammetry (drone mapping) allows extremely precise evaluation of an area and also the identification and localization of risks and accesses. This map can also be printed in multiple copies for distribution to ground teams.

The mapping technique consists of:

1- Programming a zone rollover plan mapping
2- Automatic flight as pilot monitoring to capture images
3- Recovery of images captured
4- Treatment of these images in photogrammetry software
5- The production of a 2-dimensional orthophoto mosaic map



These 2D maps can be used by an incident commander or a fire investigation team.

Depending on the software, 3D modeling can also be performed.

Attention depending on the software used, the power of the computer, the processing of the images may take several minutes or several hours.

5. GEOMETRICAL EVALUATION TECHNIQUE

This involves measuring either a distance, an area or a volume.
Obviously this technique is only useful for drone teams who do not have a range finder or mapping software.

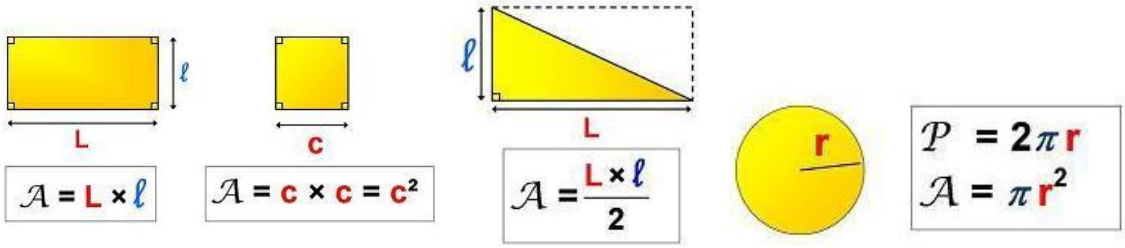
Distance measurement

The drone team can perform a distance measurement. For example, if the incident commander wants to know the distance from point A to point B. The measurement is made between the radio control and the drone.

A **B**

Measurement

The drone team can also measure an area or a volume in the same way by performing the measurements necessary for the calculations.



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6. LIVE STREAMING VIDEO BROADCASTING TECHNIQUE

This involves carrying out a live video broadcast of the aerial evolution, primarily for the incident commander. This is why it is necessary to understand your expectations dependencies on the issues of the situation to provide the best point of view.

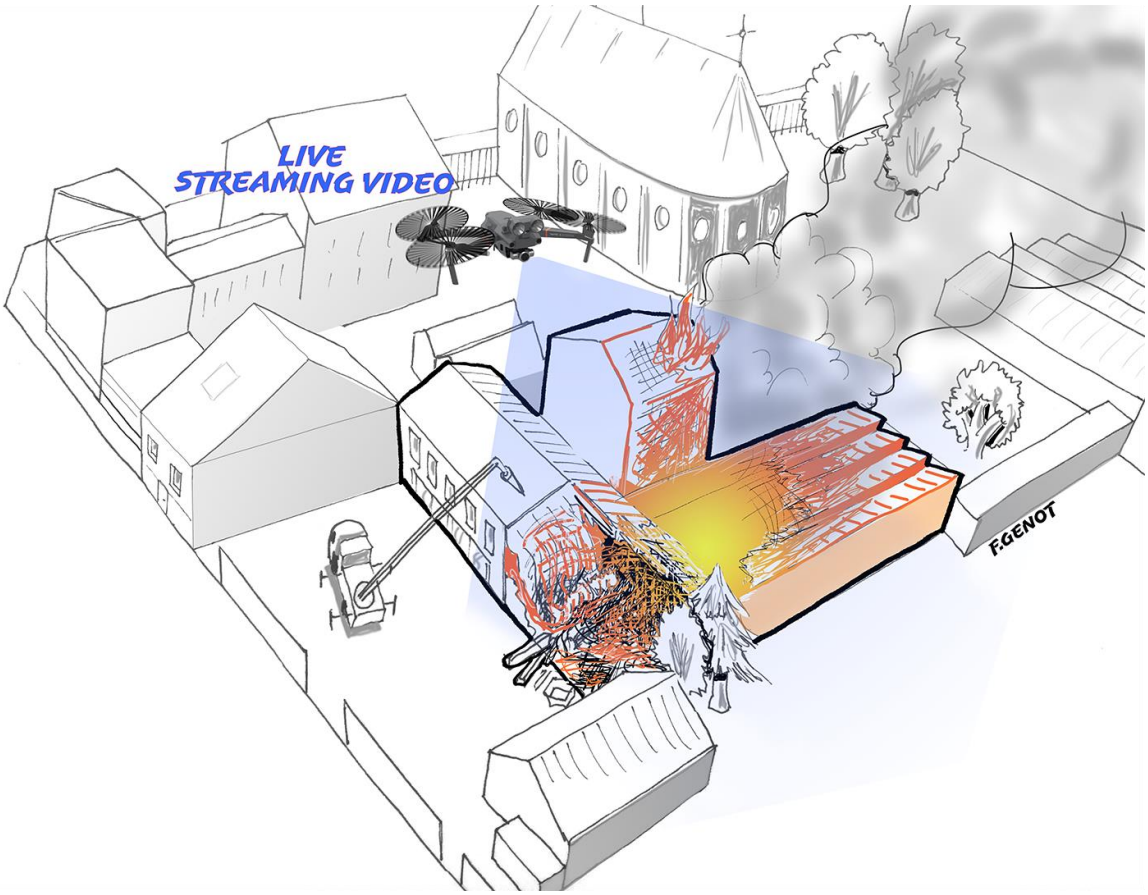
This technique helps to:

- Provide better situational awareness;
- Display the incident with the sources of danger, the flows and the targets to be protected
- Display in real time the locations of the teams and their action;

Particular attention must be paid to the framing and relevance of the images captured. The team must position the drone in a high position to obtain the best overall view.

It has been identified that broadcasting live video from an operation to the operations center can lead to abuses. The higher authorities may be tempted to impose their command from a distance, whereas very often only the incident commanding on the scene of the disaster bears the responsibility for commanding and managing the situation.

Setting up video streaming to a delay of a few minutes can appear as a way to maintain command in the field while keeping the hierarchy informed at the operations center.



7. DANGER SEARCH TECHNIQUE

This involves searching for sources of dangers or flows of dangers in order to provide information on the incident to be ordered.

The objective is to carry out a flight by carrying out an aerial reconnaissance specific to any form of danger depending on the type and situation of the intervention:

- Dangerous areas;
- Smoke;
- Propagation;
- Hot spots;
- Hazardous materials that are about to explode;
- Holes or collapses, cracks in the structure;
- Chemical products ;
- Gas cylinders

Any danger or suspicion of danger is identified, located, evaluated, qualified and precisely quantified by a snapshot and / or a video, GPS coordinates if necessary and transmitted to the incident to order.

The direction of the wind will be taken into account in the analysis and identification of the hazard.

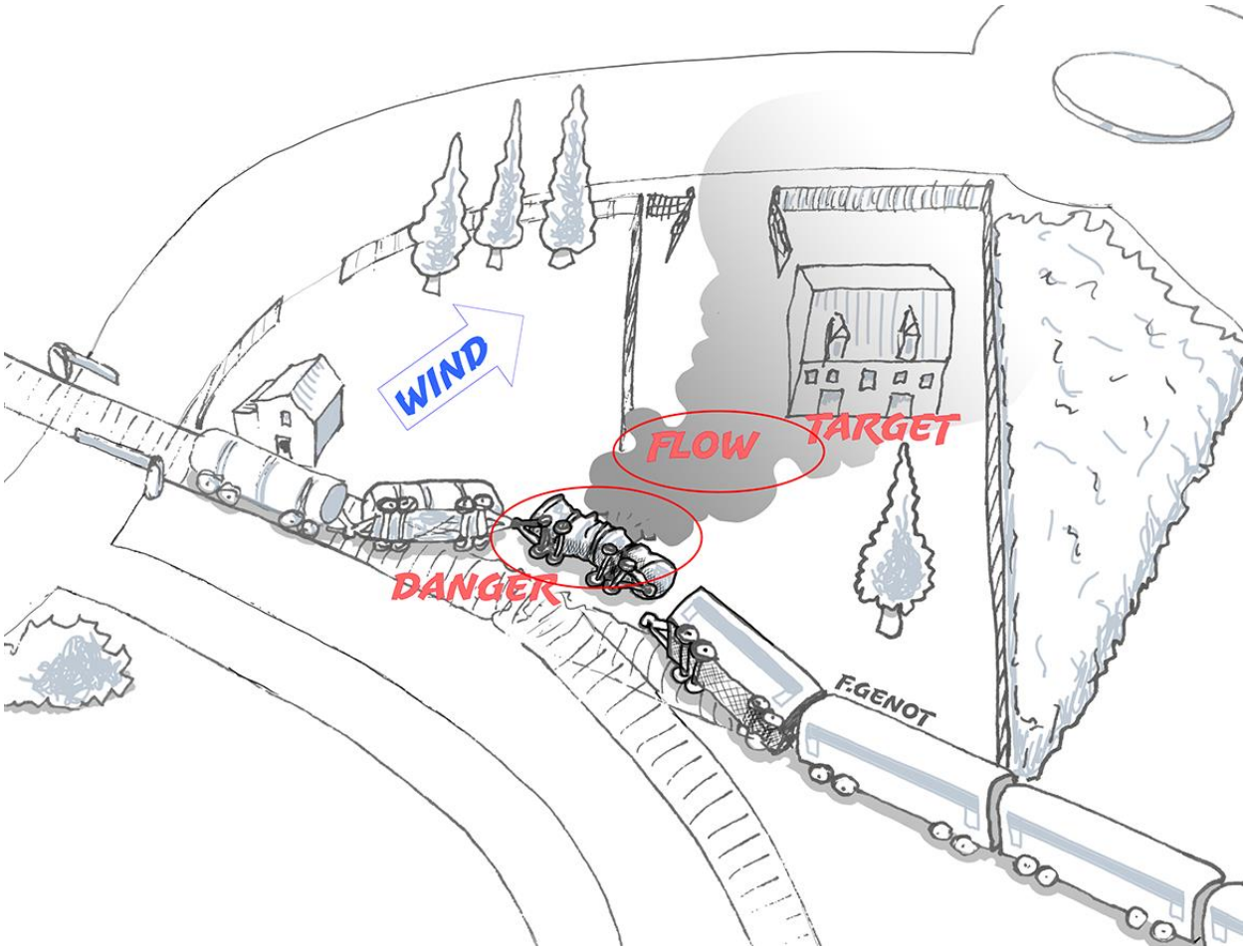
Photo courtesies of SDIS 22

8. THE SENSITIVE POINTS SEARCH TECHNIQUE

The objective is to carry out aerial reconnaissance specific to any form of sensitive point which represents a “target” exposed to a flow of danger or to the danger directly according to the type and situation of the intervention.

- The population
  - People
- The goods
  - Houses
  - Buildings
  - Vehicles
  - Highway, railway, airport
- The environment
  - The rivers
  - The forest
  - The animals

Any target exposed or potentially exposed to a danger is identified and located precisely by a snapshot and / or a video, GPS coordinates if necessary, and forwarded to the incident command.



9. CLAIMS SURVEILLANCE TECHNIQUE

The objective is to monitor and regularly monitor a disaster or situation in order to observe its development.

Several recurring flights are necessary, they can be done every hour, every two hours, etc.

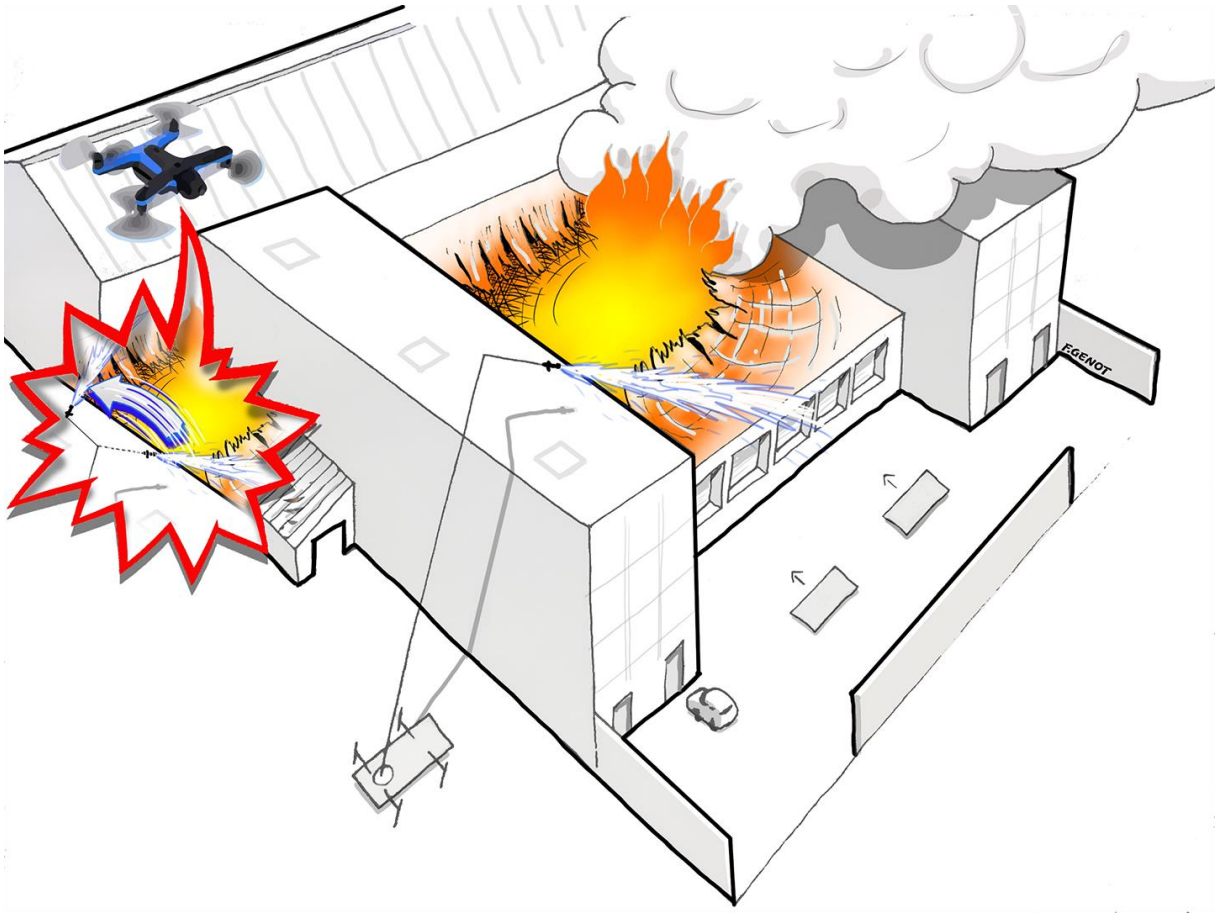
The media collected will be time-stamped in order to carry out a comparison to underline an evolution.

10. ACTION EVALUATION TECHNIQUE

This involves carrying out an evaluation of the actions decided by the incident commander.

It can be a question of evaluating by a photo or a video the action of the extinguishing lances, the ventilation, an anti-pollution barrier, an exclusion perimeter, etc.

The objective is to know if the actions are effective or not, and if necessary to act to correct them.



A. AERIAL ACTION

1. SOUND DIFFUSION TECHNIQUE

Some drones have the possibility of having a loudspeaker as a payload.

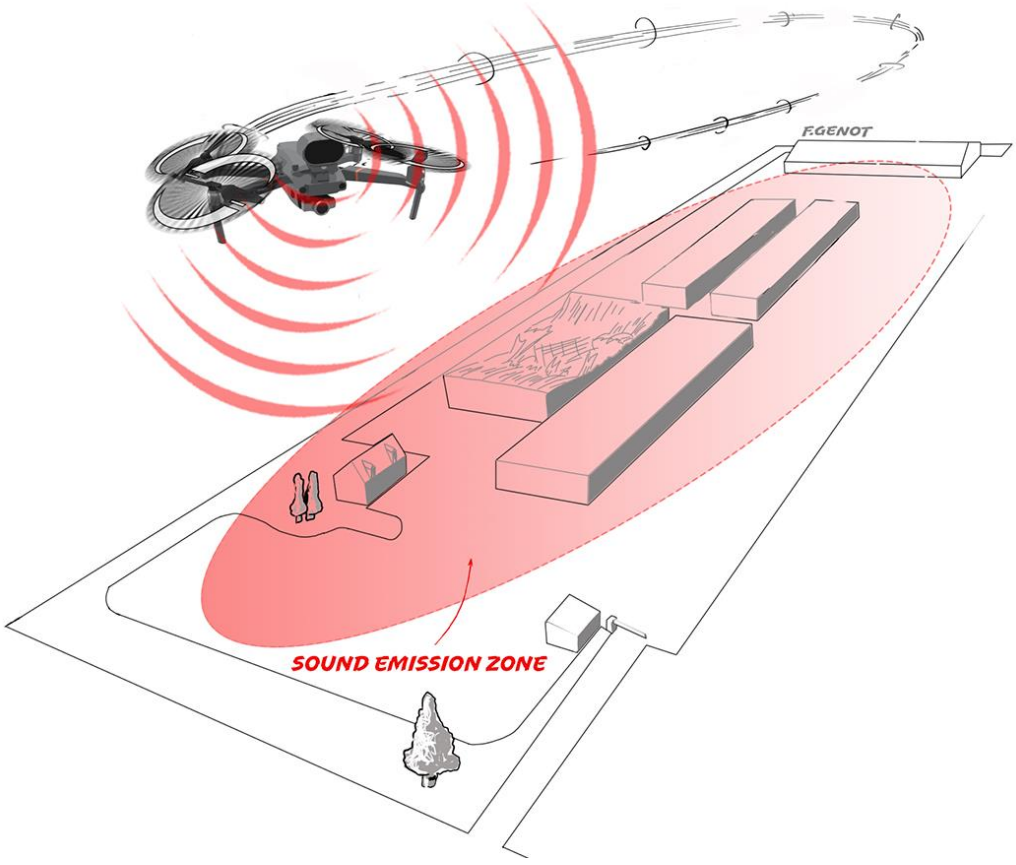
With this equipment, it is possible to generate an audible alert or broadcast an audible information message to the responders (firefighters, police) in the incident area, or to the population.

The sound messages can be varied:

- Information about the flight of a firefighter drone
- Order to wear his helmet
- Order to evacuate
- Order to remain confined, to close the windows

It is important that the sound produced is understood by the person to whom the message is intended. An adjustment test can be carried out at the start of the flight.

For a power of about 100 dB, the effective height is 30 meters.



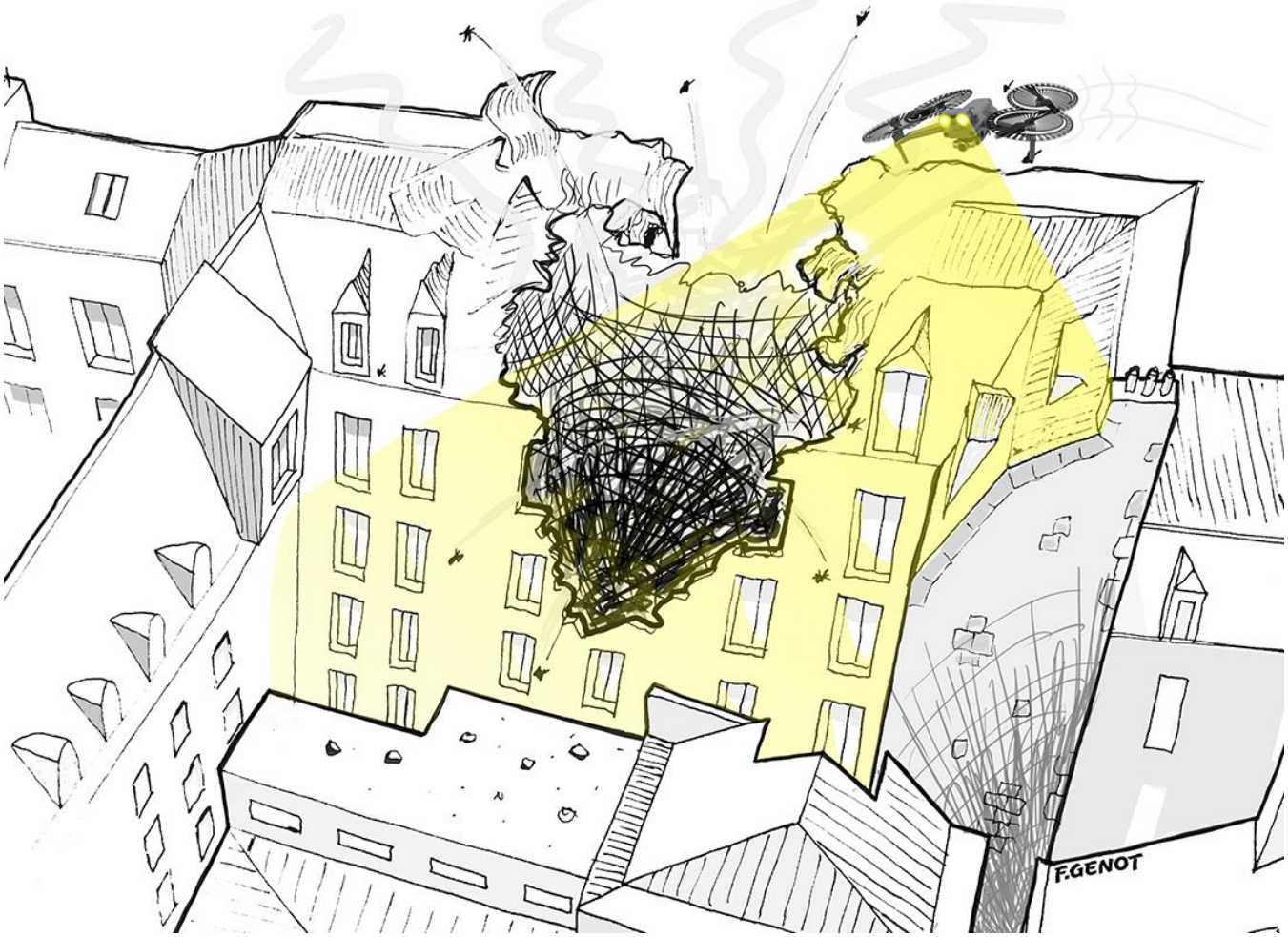
2. LIGHTING TECHNIQUE

Drones fitted with spotlights provide lighting to an area that is difficult to access.

Beforehand, the pilot must adjust the negative angle of lighting of the spots to optimize the mission.

The drone team positions the aircraft in order to illuminate the chosen area. It will be necessary to be vigilant on the higher consumption of the batteries in night flight conditions.

Anticipation of the reloading process is necessary. It will also be necessary to foresee that if a drone is assigned to this mission, we can consider deploying a second drone to carry out reconnaissance missions in parallel.

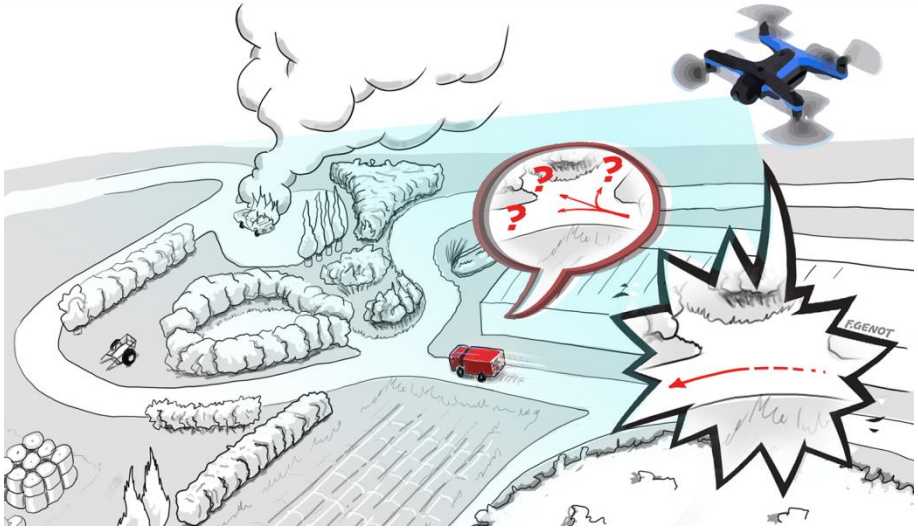


3. ACTION GUIDANCE TECHNIQUE

The objective of this technique is to provide guidance from the sky of an action on the ground (fire attack, movement, approach, etc.).

The drone team contacts the incident commander or a crew commander.
The coordination and guidance of the action is done on the tactical radio channel.

The drone team transmits by radio the actions to be carried out while keeping the visual on the ground team.



4. DROPPING TECHNIQUE

Some drones allow you to drop or drop objects. This requires the addition of an on-board sling and release system to carry and release an object from the aircraft.

In areas where the progress of ground teams is difficult, a drone can provide essential equipment for the survival or rescue of victims by air and at high speed (smartphone, radio, drugs, buoy, flotation device, water bottles. water, a rope, etc.).

Special attention must be paid to the weight of the load carried, the balancing and centering of the masses as well as the overconsumption of the batteries. In order not to exceed the maximum mass of the payload (object) by the drone, a simple luggage scale can quickly measure the mass.

Among the possibilities (non-exhaustive):

- Dropping an object (buoy, etc.);
- Installation of an object (transmitter receiver, consumable, ...);
- Removal of cord for handrail, zip line or roof covering;
- Sensor transport (sample measurement).

Meteorological restriction

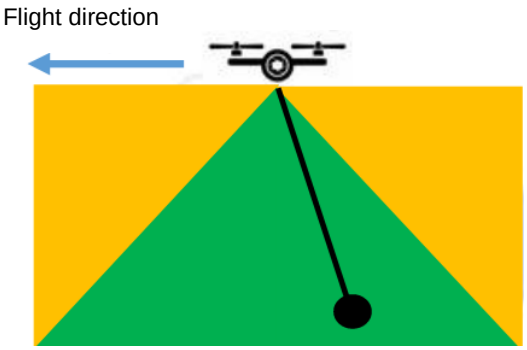
When the wind reaches 75% of the maximum limit of the device, an imbalance (aircraft and sling) may appear which creates a greater risk of accident.

Sling length (rope)

To avoid a collision between the payload and the propellers, a sling longer than 120 cm or 4 ft can be used.

Payload Balance Limitations

Depending on the wind, the weight of the payload, the sling length and current weather conditions, the pilot must ensure that the payload sling rope does not take an angle greater than 45 ° from the vertical. The pilot must pay particular attention during the take-off and ballasted landing phases. In all cases, avoid turning the controls fully or suddenly, smooth steering is recommended.

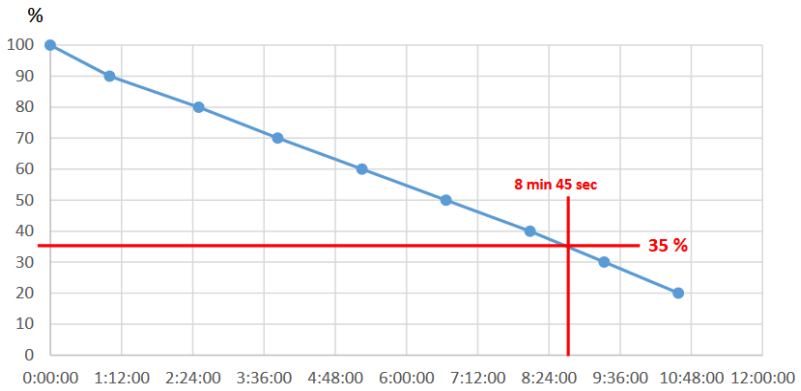


Color	Sling rope positionpositioning
	Normal zone: moving, picking up speed or slowing down
	Prohibited zone

In order to minimize the risks, sling flights can be restricted to visual flight and you should never exceed the maximum authorized weight for a type of drone.

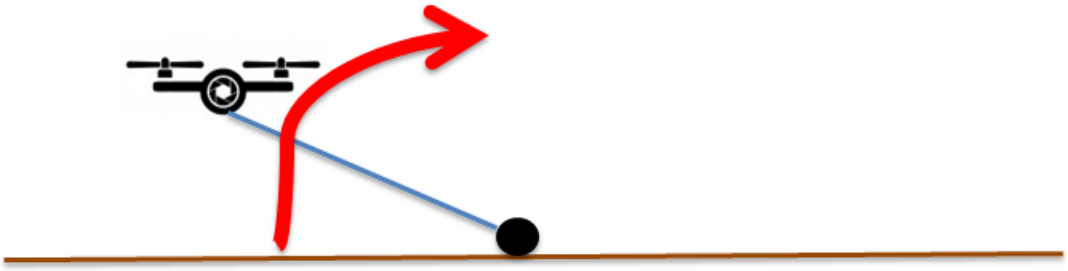
As soon as it takes off, the pilot must pay particular attention to his flight height because his size has changed (drone + sling rope + payload). The pilot must keep his sling rope as tight as possible as much as possible. For the same reason, the length of the sling must be taken into account when setting the height of the RTH (fail-safe system).

Carrying a payload in a sling strongly influences the discharge of the battery, the pilot must be aware of this at all times. To save energy, you have to avoid brutal control, energy-consuming options (lights, speaker, and strobe) and keep your batteries warm.



This diagram shows the very rapid battery discharge of a drone reaching its maximum mass. Anticipation of energy consumption is essential when implementing the release technique. The battery alert limits can be reconfigured upwards. Especially since the remaining time estimates displayed on the remote controls are often configured for the mass of the drone but not for its maximum mass (with sling and payload), so this estimate is misleading, it should not be taken into account. for the remaining autonomy.

<u>Take-off phase</u>



The pilot takes off while keeping the rope taut. He positions the drone above the payload then by applying engine power, takes off the payload and checks that:

- The release system remains in place;
- The payload remains hooked;
- The drone remains stable without the intervention of the remote pilot;
- The drone controls respond correctly;
- The absence of an alarm message on the remote control.
- Take-off will be interrupted if one of the above items is not respected.

Release of the payload

3 types of maneuver are possible depending on the mission and the payload:

- Release of the payload;
- Removal of the payload;

Releasing the payload

The pilot positions the drone vertically to the target. The height of the drone is chosen taking into account:

- Safety around the target;
- The length of the payload sling rope;
- The type of payload;
- The desired effect with the payload.

The release is carried out either without order, or with a visual order with image feedback, or audio by means of a radio.

Removing the payload

The remote pilot positions the drone vertically over the target. The approach height of the drone and the payload are greater than the target. This height is chosen taking into account:

- Safety around the target;
- The length of the payload sling rope;
- The type of payload.

The remote pilot places the payload either on the ground or in the hand of a person by controlling the deposit by means of the video feedback. The removal is carried out either without order, or with a visual order with image feedback, or audio by means of a radio.

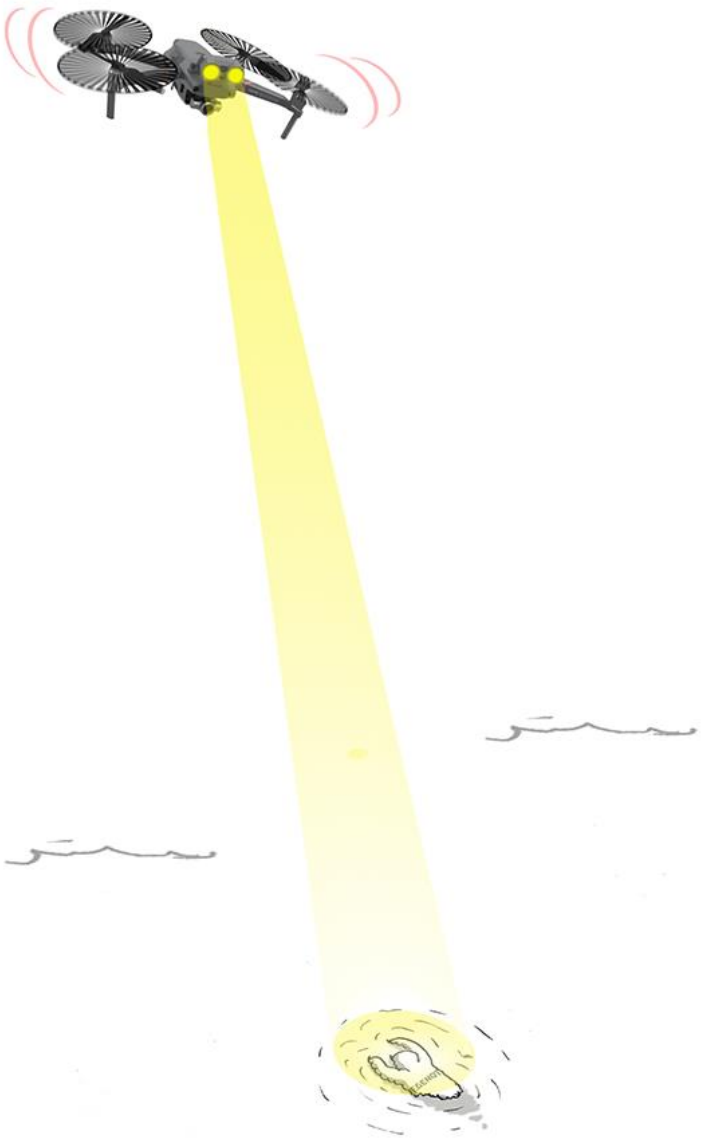
5. DESIGNATION TECHNIQUE

Drones can also be used to designate objectives or points of interest.

The interest is to be able to carry out a marking, a rapid and remote designation from the sky for the ground teams. The designated point can be a victim, a danger, an access, a particular object, a hot point.

This designation can be done in several ways:

- Physically by hovering over the point of interest (by day)
- With a light marking, by pointing a spotlight on a designated point of interest (at night)
- By dropping an object to mark the location of the point of interest (by day)



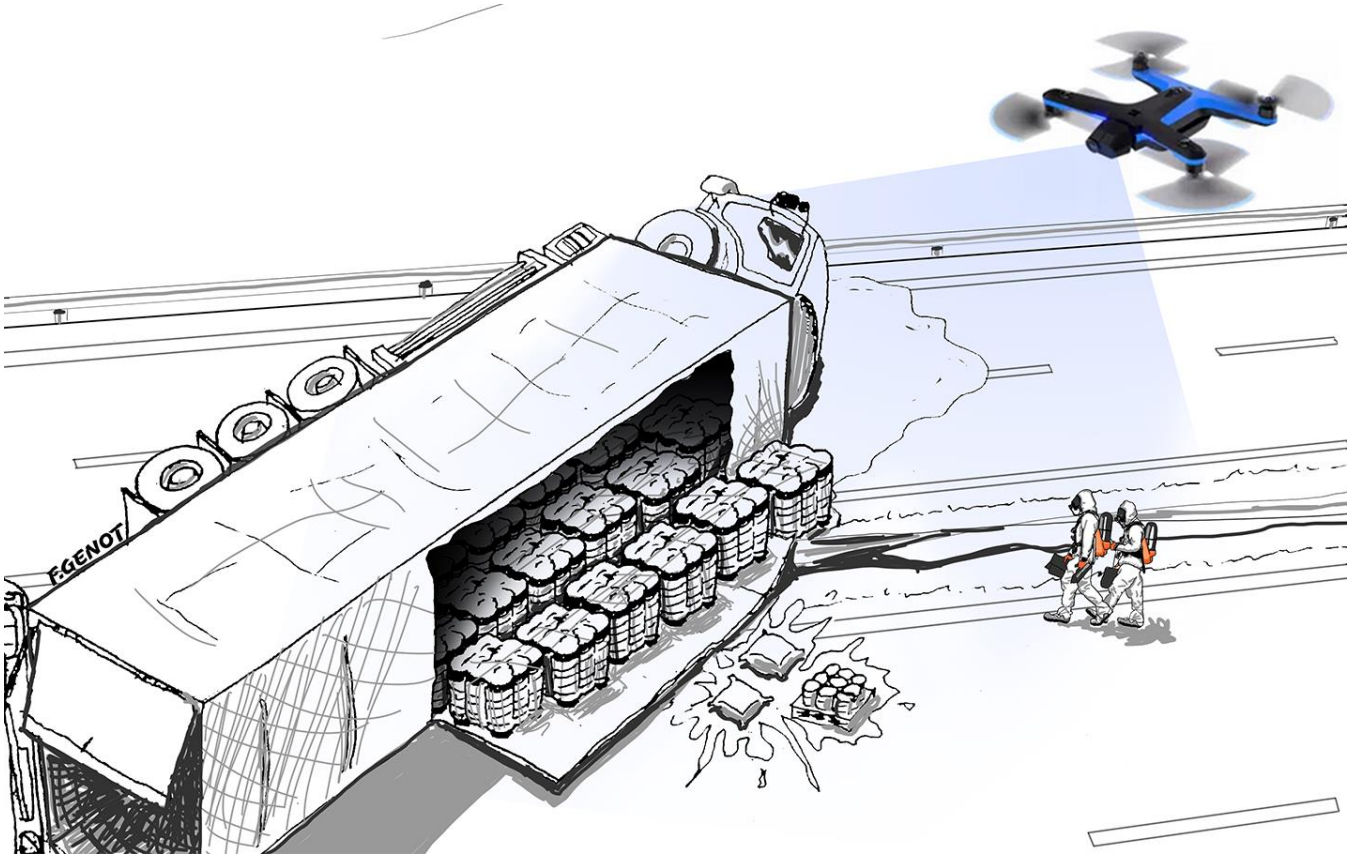
6. SAFETY ESCORT TECHNIQUE

This technique is used to perform a security "escort" of a team (or truck) on the ground in motion which enters a exclusion zone or a proven danger zone (ECBRN, Hazmat or explosion risk for example).

The aerial evolution takes place at a height adapted to the subject being followed, and to the speed of the subject. Coordination on a radio channel is essential in order to provide verbal communication to visual information for the incident commander or crew commander.

Even if the team is progressing in the danger zone, the exposure of the drone must be the lowest (dirty or explosive zone).

This technique can be combined with a video streaming technique.



7. SPECIFIC TECHNIQUES

A. VICTIM SEARCH TECHNIQUES (SAR)

Search and rescue (SAR) consists of searching for and providing assistance to people who are missing or in difficulty, in imminent danger following an accident or natural disaster.

Missing persons can be vulnerable people such as:

- Lost children (disabled or not)
- Elderly people with mental disorders
- Or suicidal people who do not wish to be found

People in distress can be in danger as a result of road accidents (“Ejected” from the accident at night, for example).

Normally, research is divided into different areas of expertise depending on the environment where the research takes place:

- Urban;
- Mountainous;
- Rural;
- Aquatic;

With each type of search area, the procedures used are also different and the missions performed by drones also vary.

While in the water, it appears important and essential to be able to release a life jacket or flotation devices, while in urban areas, it is more useful to have good video quality and a zoom to distinguish between people.
In the mountains, you need equipment (thermal if possible) capable of withstanding low temperatures and harsh weather conditions.

Thus, for each type of search area, specific procedures and equipment must be used to optimize the mission and increase the possibility of finding the missing person.

The success of the search depends primarily on starting the last place the person was last seen as early as possible or most likely places they could be. This should be accompanied by a large participation of ground research teams with; if possible, dog teams because they are complementary to the drone teams.

It is always important to maintain a good flow of information and good communication between all the teams. This coordination makes it possible to carry out doubts by land / dog teams on identified thermal traces

1. URBAN ENVIRONMENT

Research in cities is a difficult place to carry out research, especially if the mission is to find a specific person, but the best practice is quick action. Here are some of the steps you can take to get started:

- Gather information about the victim and the background;
- Start the search from the place where the person was last seen;
- Methodical search for authorized flight zones;

Important reminders

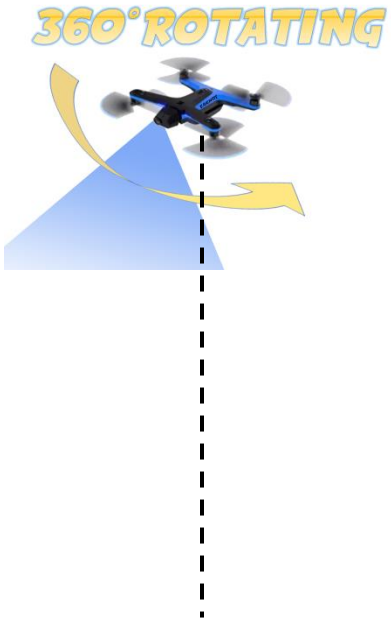
According to national drone regulations, urban drone flight may be prohibited even with an exemption. The principle of precaution and safety prevails, flying over an entire city looking for a person may not be a good idea. You must always take into account the risk of drone falling and therefore avoid flying overhead.

An easy, fast and safe technique is that of the vertical ascent which is adapted to the urban environment.

The technique of vertical ascent

To avoid flying over streets and the public and carry out a quick initial reconnaissance, you can:

1- Make a safety perimeter of 5 to 10 meters to keep the public away
2- Take off and perform a vertical ascent with the drone (without navigation) Use
3- The 360 ° rotating technique to observe the surrounding environment to look for the victim nearby.



2. COUNTRYSIDE

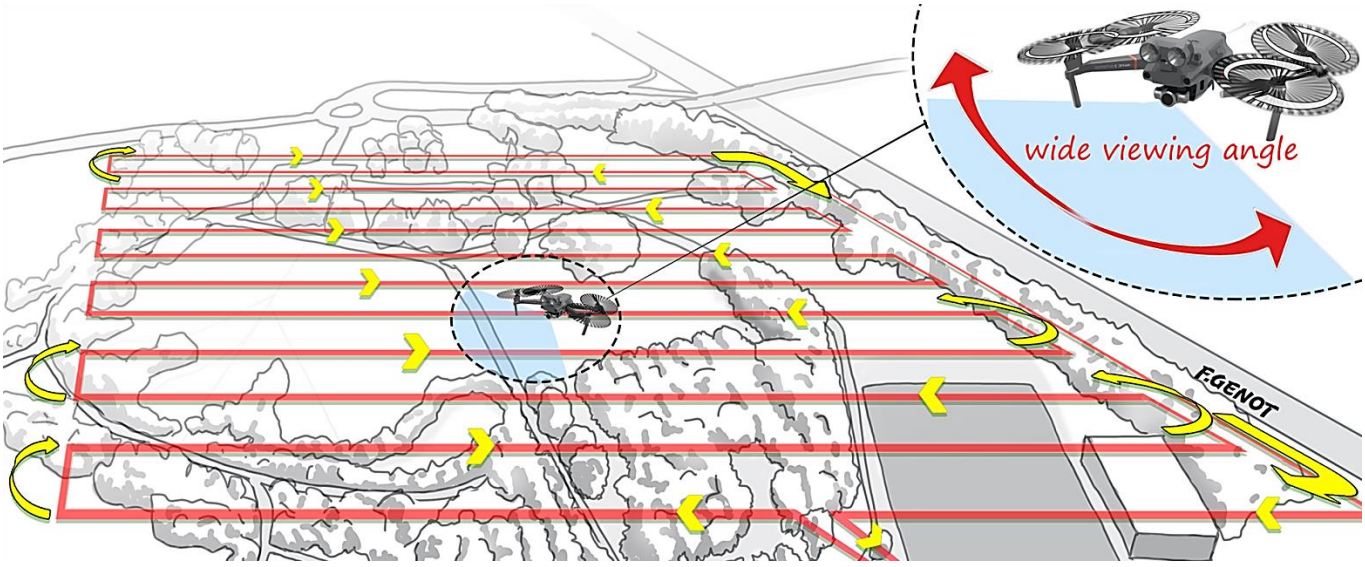
Unlike urban areas, rural areas (in the countryside) are much more conducive to the search for victims. The flights are less risky and it is sometimes possible to do out of sight navigation (BVLOS) with drones.

Without being exhaustive, here are some victim search techniques:

The comb technique

After delimiting the search area and the search height (free of any obstacle), making a grid allows you to rake the area. This evolution can be done either manually (risk of a random search and fatigue) or by means of a pre-established automatic flight plan (less fatigue and more concentration on image analysis) using either a load useful electro-optic or thermal.

If necessary, the team leader can request the deployment of observers along the route of the drone's flight.



Thermal and zoom capabilities are very effective in identifying missing persons. The thermal contrast of the victim with his environment makes it possible to locate him quite quickly. The zoom makes it possible to remotely raise doubts on thermal signatures.

Before any search for a victim or person using the thermal camera, the pilot must calibrate the temperature range visible on himself, in order to optimize the visualization of hot spots corresponding to a human thermal signature in the conditions of the intervention.

In the absence of a thermal and zoom camera, a visible camera is the main tool for carrying out searches during the day. The best search results are at a height of 40m with a slight inclination +/- 45 ° to better visualize in depth.

A loudspeaker on a drone can be used to call the name of the missing person or to give him instructions.

Recording everything in video can allow the images to be reviewed in high quality (looking for detailed clues), if possible using artificial intelligence (AI) analysis.

During this delicate search phase, viewing the victim on a tablet or smartphone screen is quite difficult to discern the victim.

Some drone teams carry out an image transfer on a larger screen (the size of a TV screen or larger, and if possible in high definition) with a person dedicated to image analysis to benefit from 'better visualization.

The light technique

As part of a night search for a lost person or an injured victim who is in telephone contact with the emergency call center or the pilot.

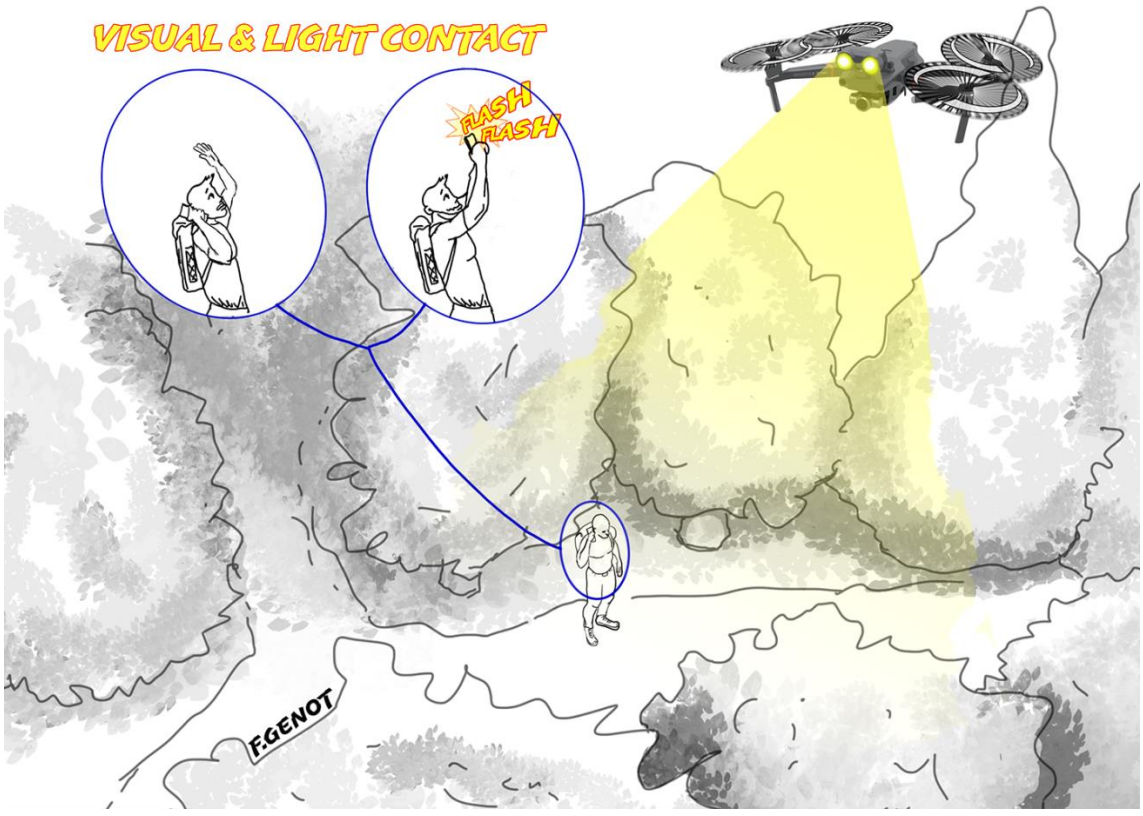
2 possibilities exist:

a) <u>The victim sees the drone thanks to its lights (search light)</u>

The victim can thus guide the drone towards her to be located. Be careful, a misunderstanding can appear if the victim and the pilot do not speak from the same right and the same left.

If the victim sees the drone heading towards:

The left	Point the drone on the right
The right	Point the drone on the left
The bottom of the sky	Turn around
The top of the sky	Stay on course



b) <u>The victim does not see the drone</u>

By phone, ask the victim to turn on his smartphone light and point it towards the sky. If the victim is within visual range, a light point will appear to indicate the location of the victim.

For all these techniques where the victim is on the phone during the search operation, it is imperative to recommend that the latter hang up from time to time and save his phone battery.

3. MOUNTAINS

Search and rescue in the mountains refers to large areas where there are not many people living or moving around on a regular basis. In addition, the mountainous environment is hostile from a meteorological and topographical point of view.
And for this particular reason, it is difficult to find missing people in this environment.

When using drones in mountain research, certain sensitive points must be taken into account:

- Low or negative temperatures affect the drone's batteries and therefore its autonomy. Each aerial evolution must be energy efficient.
- The mountainous relief imposes vertical climbs beyond 120m in height because of the steep drop. The pilot can quickly find himself at a height of 500m or more without going beyond the highest point.
- Beyond the mountainous terrain, one frequently observes strong turbulence generated by wind eddies.
- At the bottom of the valleys, the GPS signal can disappear. Only manual or ATTI mode will be available for the flight.

All these extreme and particular conditions require very specific training for pilots. You cannot improvise a drone pilot to search for victims in the mountains.

Some good practices can help increase the chances of finding the missing person. These points are:

- Carry out a deep investigation of the victim who disappeared in the mountains. What clothing? What route or path the victim had planned? This investigation will provide the main track followed by the victim and therefore an essential point of reference for organizing the research;
- Reconnaissance by following the trail from start to finish;
- Extend the reconnaissance on the outskirts of the path by imagining a fall scenario;
- Perform the comb technique on adjacent unrecognized areas.

The object drop feature can be extremely useful in this particularly inaccessible environment. It can make it possible to deliver objects and tools to mountain rescuers but also food or means of communication to the victim.

4. AQUATIC AREAS

Aquatic search and rescue are carried out in lakes, rivers or at sea to save people in distress. When a vessel in distress or a missing person is located, SAR organizations deploy helicopters, rescue vessels or other suitable vessels to provide assistance and bring them back to shore.

It will therefore be necessary to be careful about air coordination between the possible maritime rescue helicopters.

It is important to begin the search as soon as possible around the place where the person, boat or plane was last seen. Collect accurate and recent information as well, which could help you a lot when defining search grids (comb technique) for starting and expanding searches.

Speed is crucial in these scenarios because people can drown, experience hypothermia, or be swept away to a completely different area.

To increase the chances of success, some equipment and improvements are important, such as:

- Extended flight time (to be further from take-off which can be a slow boat and inspect a larger area);
- Thermal vision and high resolution to be able to fly high and capture large areas; pay attention to the calibration of the thermal camera because sometimes the water is hotter than the ground and / or the victim;
- Release system to bring a life jacket to the victim.

By using a drone, it is possible to see up to about 5 meters underwater where the person was, helping divers find the person faster in addition to their standard search.

A best practice is to divide the search areas between divers, drones, using the right resource for the right area. When drone teams find something, they must alert divers to check the area and if necessary perform the rescue, allowing a larger area to be covered more quickly.

5. COORDINATION OF DOG TEAMS

Sometimes perceived as competing, drone teams and dog teams are indeed complementary and in the interest of the victim.

Good communication and coordination is essential when working with dog handlers. The tactical radio channel must also be powerful because sometimes the distance between the teams can be important.

Training with dog teams is important to learn their behavior and communicate with handlers to help locate the victim.

Two techniques exist for this drone / dog coordination:

Distribution by zones

Drone teams are assimilated to a search team like dog teams. In a wooded area, the dog will be more efficient than the drone in scanning this very dense area.
In a field or open area, the drone will be faster than the dog to sweep large areas.
The incident commander can therefore divide the global area into several search sectors depending on the density of vegetation, 1 sector 1 team (either drone or dog).

Coordination on the same sector

The incident commander can also affect a dog team and a drone team in the same search sector.

The drone team's mission is to detect suspicious thermal signatures (victim or animals, hot stones, other people) and then to guide the dog teams to remove doubts. This makes it possible to reduce the dog's search time and thus reduce his fatigue.

The luminous or vertical stationary designation technique can facilitate the movement and guidance of dog teams in the area to be treated.

You can also use the drone team to monitor the dog team (**security escort technique**) and follow by recording every action to ensure their safety, monitor progress and track their position.

B. FIREFIGHTING TECHNIQUES

1. STRUCTURAL AND INDUSTRIAL FIRES

Structural fires are associated with unplanned, undesirable and uncontrolled combustion and fire initiation related to residential, commercial or industrial infrastructure.
The infrastructures involved can be broken down into the following scenarios:

- House fires
- Apartment fires;
- Fires in stores or shopping malls;
- Business and warehouse fires

This type of fire is mainly treated by fire vans and ladder trucks. For house and apartment fires, the usefulness of the support of a drone team is reduced because the volume of the fire is small. Nevertheless in some cases, if the fire concerns the roofs of these dwellings, the drone team can bring a real added value to bring to the incident command a more detailed view of the roof and the hot spots. In the same way, the guidance technique can be used to carry out a guidance of the clearing of the roof (for example).

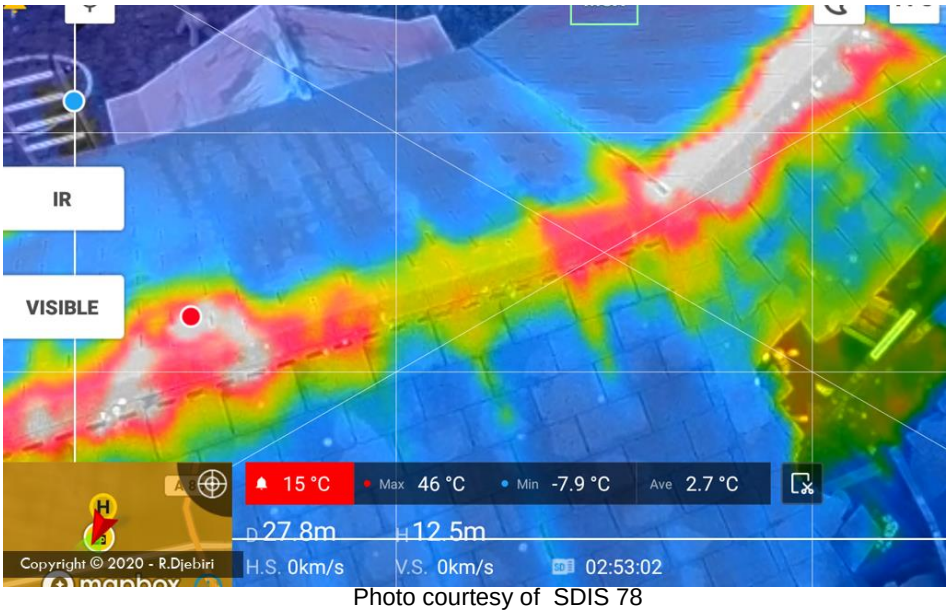


Photo courtesy of SDIS 78

The principle being to visualize the hot spots on the roof with the thermal camera of the drone and to communicate to the crew to command or the incident to command which part of the roof must be removed.

For shopping center, business and warehouse fires, the area of the disaster is much larger. The reconnaissance and the overall assessment of the incident are more complex and take longer for the incident to be ordered. In this context, the drone team, if it is hired early, can be of great use in ordering it for a better and faster understanding of the situation.

The techniques to be used in this operational framework are numerous:

DURING THE RECOGNITION PHASE

The spiral technique can quickly bring to the incident commanding a vision of the 4 facades of the building, its roof and the overall situation with the accesses. This first visualization can be combined with thermal imagery to locate the main focus and the axis of propagation. In addition, this first collection of photos / videos (carried out in less than 5 min) saves the incident controlling reconnaissance time on foot all around the building and also allows data to be preserved.

The drone team can also identify the direction and the force of the wind to report on the incident to order to anticipate the effects generated on the current fire.

If early aerial or ground reconnaissance makes appear at a window a victim to be saved from the flames and smoke, **the object dropping technique** can be used to drop or drop a hood of fumes to the victim while the ground teams carry out the rescue with ladders.

Photo courtesy of London Fire Brigade

In parallel, **the sound diffusion technique** makes it possible to explain to the victim how the rescue will be carried out and to give him safety instructions, but above all also to reassure him until the firefighters reach him.

The 360 rotating technique is also useful for quickly visualizing the direct environment of the damaged building and for anticipating a domino effect or fire propagation.

One of the concerns of the incident commander will be to estimate the area of the damaged building or the area that is burning. This estimate has never been an easy thing to order them all. With a drone, we can evaluate or calculate the desired area more or less precisely:

- In the absence of mapping software, we can use **the geometric evaluation technique.** This method may be approximate but it is very quick since a few minutes will suffice to measure the length and width of the building. If the drone has an on-board rangefinder, it's even faster to measure a distance.

- With mapping software, **the operational mapping technique** will be a little longer but extremely precise. The orthophoto mosaic generated by the software makes it possible to carry out all the desired distance or area measurements on the scanned area.

Sometimes the plume of smoke created by the fire can be extremely toxic and impact the urban and rural environment. A high-rise, perspective shot can highlight the orientation of the smoke plume and the suspected impact.

DURING THE ATTACK PHASE

During the attack, sometimes the high power lances are not always correctly oriented (on scale or not) due to lack of visibility or optical effect.

The thermal imaging of the drone can be put to good use through the action evaluation technique, then in a second step through the attack guidance technique.

- **The technique of evaluating actions**, the incident commander can entrust the mission of evaluating the effectiveness of the spears in extinguishing or stopping the spread (or other missions). The drone team performs its flight and evaluation with the thermal camera in order to visualize, capture and analyze if the action seems effective.

- In the event that the action (the attack for example) is ineffective or partially effective, the drone team can propose corrections to the incident commander or to the crew commander to carry out **attack guidance**, the principle being to visualize hot spots and communicate to the ladder truck control crew (for example) any corrections to be made to the orientation of the lance.

Photo courtesy of SDIS 77

During this attack phase, **the technique of live streaming video** allows the incident command to view the disaster and the actions in progress live and possibly to coordinate actions in parallel.

In the event of a risk of explosion (gas or acetylene bottles), sometimes the incident commander orders the implementation of a moored lance without exposed personnel. The drone can be used with **the technique of the security escort** to ensure the security and monitoring of the team that will set up and moor this lance in the explosive zone.

On the other hand, if a drone team is assigned to this technique, this mission; it is consequently monopolized and blocked on this action. No other mission can be entrusted to it (reconnaissance, guidance, mapping, etc.), which may require the reinforcement of a second drone team to perform other missions in parallel (see below **the coordinated overwatch maneuver**).

DURING THE SUPPLY PHASE

During this phase, the drone can be used:

- Either to locate the nearest water point or the peripheral water points to supply the fire vans.
- Either to measure the length of the fire truck to a river for the establishment of a hydraulic supply line using the geometric evaluation technique, or by using an on-board range finder

DURING THE SURVEILLANCE PHASE

The monitoring technique consists of to carry out regular control and assessment flights of the disaster, of the potential presence of resumption of fire.
Temperatures should be noted and archived for comparison with previous measurements.
An automatic flight plan can be established in order to always achieve the same flight with the same angle and the same flight height (for comparable measurements).
The recurrence of thefts depends on the area of the incident. A theft every 30min corresponds to a small area disaster, for medium and large areas the minimum is one theft every hour.

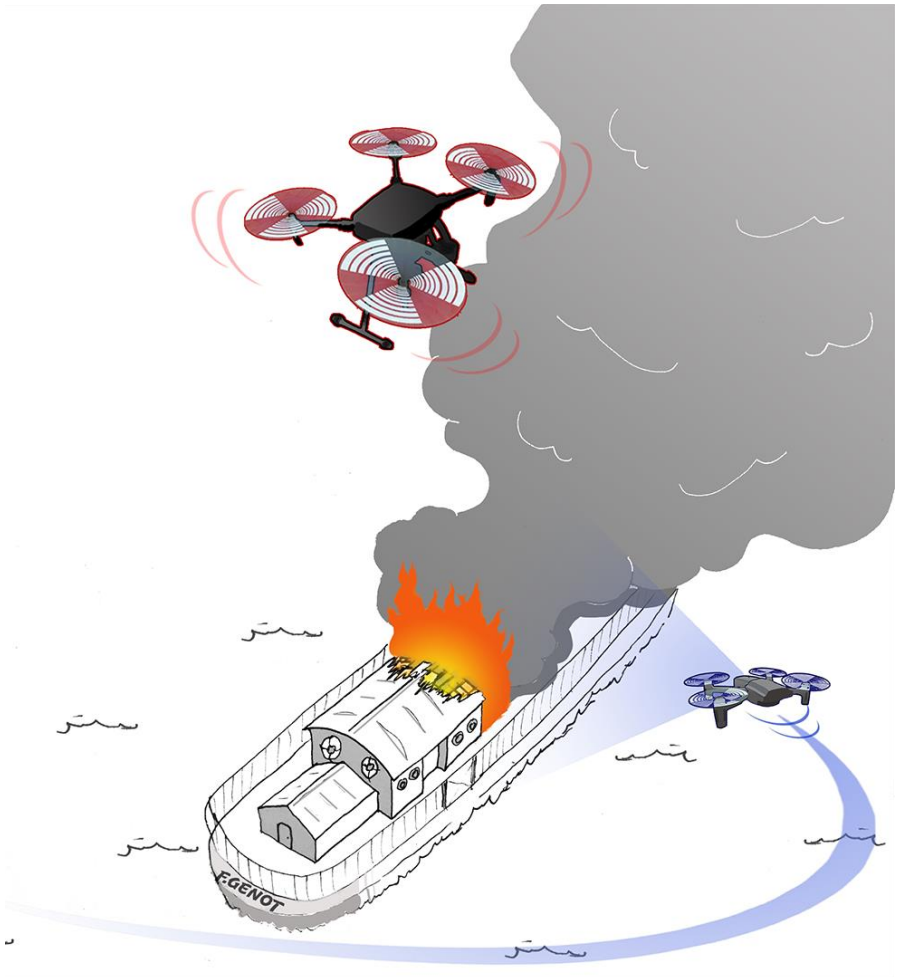
During all phases of a night fire operation, **lighting technology** can be useful especially if conventional lighting means are not suitable or if the area is inaccessible.

Photo courtesy of JVP Grada Zagreba

The Coordinated Overwatch maneuver

When the disaster is large or complex, when several missions are required simultaneously, the deployment of 2 or more drones may be a solution.

- The 2 drone teams establish their respective TOLA in the same area.
- A TOLA manager is appointed to manage take-offs and vertical landings (only one at a time) and provide air coordination. He is responsible for the vertical segregation of drones on the flight sector.
- The1st drone is positioned very high above the incident at a defined height. The mission of this stationary drone is to visualize and supervise the entire incident area, to assess hot spots and fire spreads, and possibly to carry out the video streaming technique. This drone is referred to as the overwatch drone.
- The 2nd drone is positioned on a lower height; it must be fast and mobile to carry out brief reconnaissance, thermal assessments on the facades (ABCD), possibly a mapping technique. This drone is referred to as the tactical drone.



2. WILDFIRES

Forest fires, wildfires, peat fires are associated with unplanned, unwanted and uncontrolled combustion and normally associated with combustible vegetation. Depending on the type of vegetation, the terrain and the weather conditions, this will affect the intensity, the dimension of the speed of propagation of the fire.

A quick and strong attack in its early stages is needed to prevent a major forest fire that can last for days, weeks or even months. But speed and strength are not always effective if there is no information about the conditions of the wildfire and how the fights are going in the different sections of the fight. These same rules apply for field fires, peat fires, bushfires, etc.

Photo courtesy of Slovenian volounteer firefigthers Association (Gasilska zveza Slovenije)

IMPORTANT REMINDERS - DANGERS

Meteorological risk

The drone teams used in forest fires must be aware of the strong convective winds that can be generated by the fire, smoke which can make flight impossible through visual observation and also temperatures which can damage the components of the drone. In this specific situation, weather conditions can change extremely quickly. Distrust and Caution

Required Air Hazard

Drone pilots should always be aware of other aircraft (such as helicopters and airplanes) which are involved in the incident and which may be damaged or damage the drone. When an emergency manned aircraft flies over the area, the principle of safety requires the drone to land. Radio communication between aircraft can help coordination a lot.

Topographic risk

Trees (burning or not) remain aerial obstacles for drones, just like high-voltage lines. The analysis of obstacles must be even more in-depth in this situation of forest fires or natural spaces (especially in the presence of smoke).

DURING THE RECOGNITION PHASE

If the drone team arrived early, it can be useful with **the technique of searching for sensitive points** by quickly carrying out a reconnaissance around the axis of fire to identify homes, a school, a high voltage line, a railroad, etc.
Thus, if a sensitive point is threatened by the flame front, the drone team can quickly notify the incident by radio or by imagery.

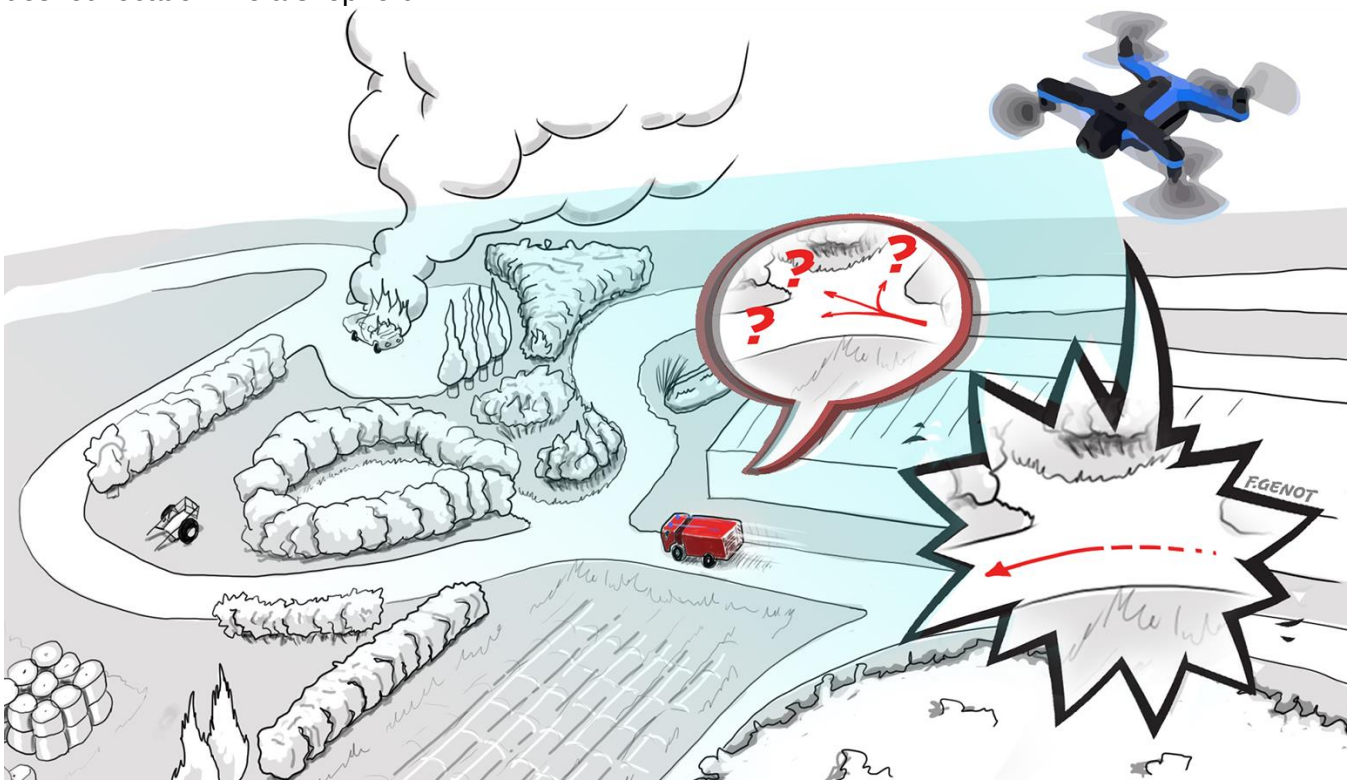
Photo Courtesy of SDIS 78

If a house is identified as a sensitive point on the way to the flame front, we can consider commissioning a drone team to carry out **a sound diffusion technique** to broadcast the instructions to urgently evacuate the house threatened by fire (in the 'waiting for ground reinforcements).

The length of the flame front can be measured either by **the geometric evaluation technique** or by a range finder.

Likewise, water points or refueling tanks can be identified and located **using a spiraltechnique** or **360 rotating**.

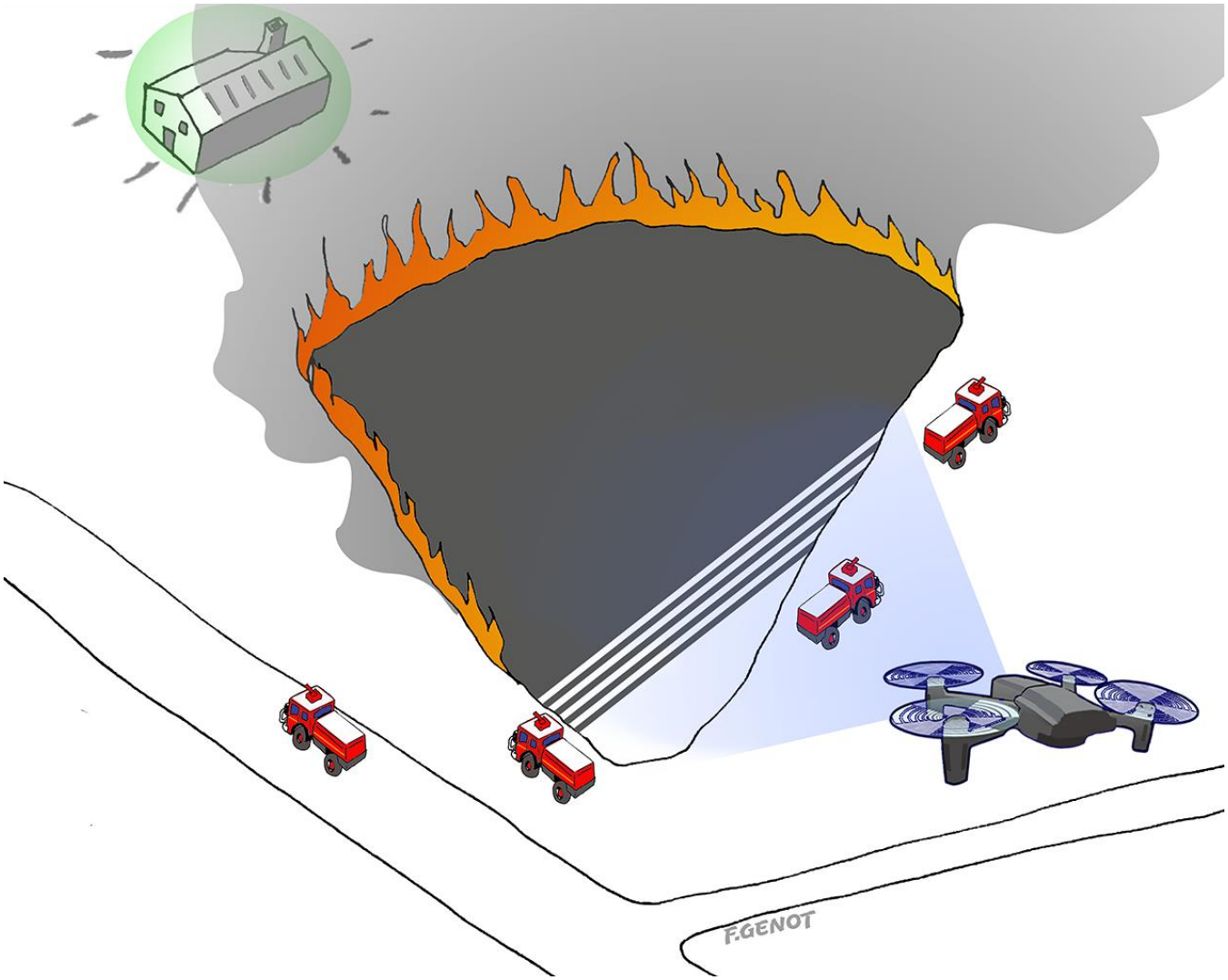
If a fire truck cannot find access to the fire or is lost in its recognition, **the shepherd technique** is a variant of the action guidance technique since it consists of guiding the vehicle by radio to bring it to the desired location like a shepherd.



DURING THE ATTACK PHASE

The live video streaming technique is particularly suited to this phase of fighting forest fires or natural spaces. Because if the incident commander can view, on his smartphone or on a screen, the entire fire zone and the location of the vans in real time, he can then command and coordinate the actions of each team on the ground. The goal is to provide real time situation awareness so that resources are moved to the best locations.
With this information it is possible to elaborate plans to stop the fire, slow it down or even redirect him to areas where it can do less damage. Even assessing the efficiency of the plan is important to define future strategies to extinguish the wildfire.

Be careful once again, this technique will block a drone team on a framing of the overall situation; the deployment of a second drone team can make it possible to carry out additional missions simultaneously (search for sensitive points, thermal evaluation, mapping and evaluation of area).



Moreover, **the overwatch maneuver** is also suitable for forest fires and natural spaces.

A **security escort technique** to monitor one or more fire trucks can also be considered if the situation requires it (danger).

DURING THE MOP-UP AND COOLING PHASE

Once a wildfire is under control, it is necessary to evaluate and define the damage extension and keep surveillance over the area to locate reignited spots. Drones can help ground teams to search for hot spots by:

- Guiding teams in cooling phase with thermal images (cooling guidance technique)
- Checking and monitoring hot spots (danger search technique);
- Mapping affected areas;
- Monitoring ground teams (technical escort);
- Calculating burnt area (technical mapping);
- Finding materials left behind after a long-term forest fire effort (it always happens)

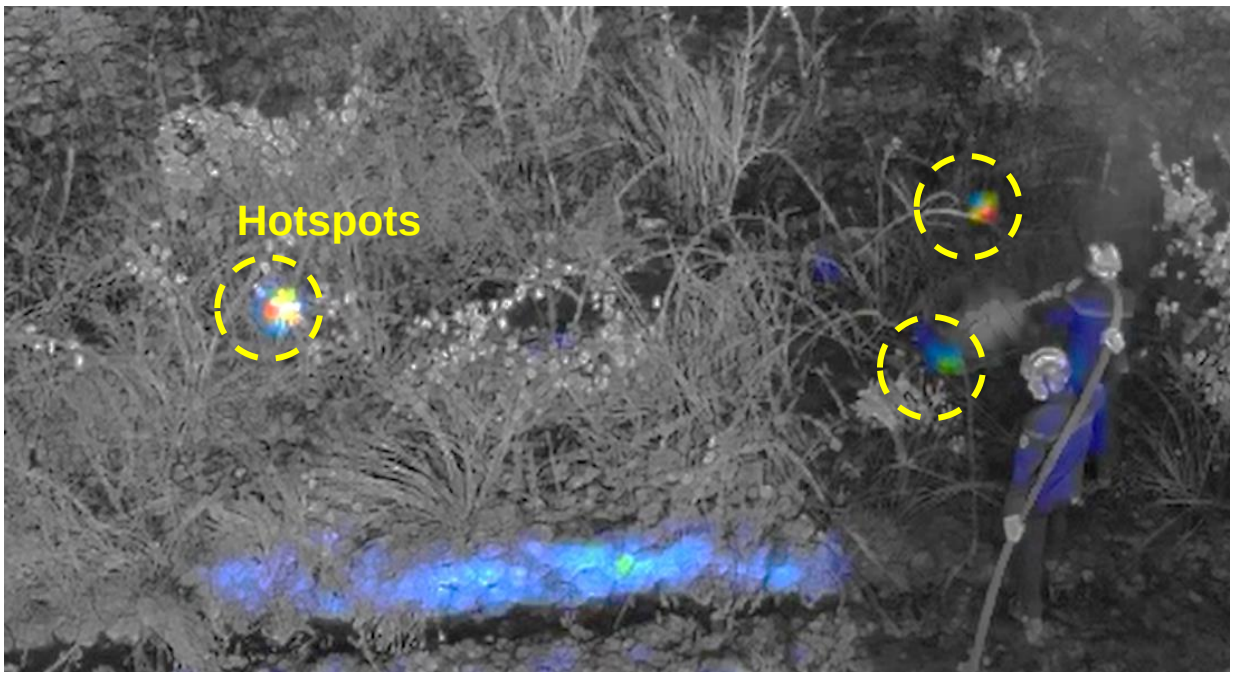


Photo Courtesy of SDIS 78

DURING THE SURVEILLANCE PHASE

Surveillance is an essential and final rule of forest fire fighting. The aim is to check regularly if a fire outbreak is not developing at ground level.
The incident commander may decide to set up monitoring in the form of periodic and recurring checks. A drone team can perform **the surveillance technique** to detect hot spots. The recurrence of thefts depends on the area of the incident. A theft every 30min corresponds to a small area disaster, for medium and large areas the minimum is one theft every hour.

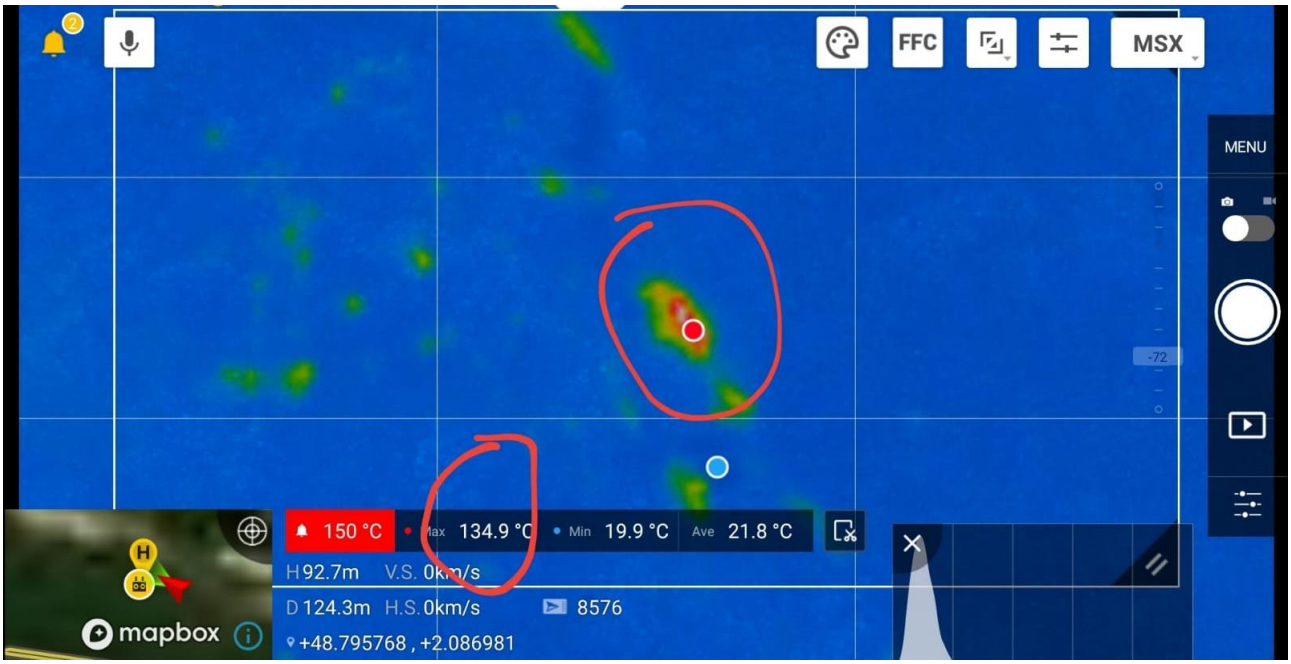


Photo Courtesy of SDIS 78

C. FIRE INVESTIGATION TECHNIQUES

The function of fire investigation is a critical element to learning from past events and applying those lessons to future activities aimed at preventing recurrent fires. Whether any fire is accidental, intentional, or weather related the process of a thorough and complete investigation will identify the factors which caused or contributed to the fire. The lessons learned from that investigation are to be applied by society in many ways to prevent or discourage future fires from closely aligned factors and circumstances.

The drone camera is an indispensable extension of the documentation phase of the fire investigation. If nothing else the drone footage, whether video or multiple still frames, provides a record of the fire's growth, spread, behavior, and impact of fire suppression from a visual perspective (point of view) which has not been previously available and going forward will likely become more and more critical in developing the account of a fire.

While it is not impossible to believe that a drone may someday capture images of a fire's initiation & origin the practical reality of the matter is that today's drone will most likely provide enhanced overall scene documentation. There is no reason to think that a drone will replace the boots on the ground fire investigator working the fire debris and using traditional digital cameras but there is also no reason to discount drones as being a necessary tool in the fire investigation toolbox or a resource that can be brought to a fire scene to contribute to overall incident documentation.

Photo courtesy of SDIS 22

ALWAYS RECORDING

If the fire department handling fire extinguishment is already operating a drone to provide live-feed of the fire scene and operations they should be simultaneously recording the live-streaming video even if there is no evident need for it by suppression forces as it can be very valuable for investigators who may arrive later in an incident, or possibly even day (s) later. This applies whether the fire department done is recording video or using a thermal imaging device to monitor fire progression or rescues. Whenever a drone is operating at a fire scene it should be recording as well. The value of the footage may not be immediately evident but you won't necessarily know what it captured until you have the chance to review it under controlled conditions.

When operating a drone during the investigative stage, after extinguishment, plan your drone flights and image captures ahead of time to ensure you capture BOTH still digital photographs and video. While the ability to playback video may be highly desirable and provide convincing evidence of fire growth and progression keep in mind that you cannot insert a video clip into a report like you can easily insert a digital photograph. Similarly, when it comes to potential litigation and prosecution there are distinct advantages & disadvantages to both still photos and video clips depending on the circumstances so it's best to have your fire scene captured using both so you can fit any need of the case presentation.

When capturing drone photos as part of the investigative process keep in mind that these images are no less evidentiary than what the investigator captures using a handheld camera. The same measures and precautions must be applied to the capture, handling, and archiving of drone images to ensure ongoing reliability and future admissibility. There is presently no difference in image admissibility rules for drone images compared to handheld cameras and don't think of them any differently.

HIGH RESOLUTION

Getting a high resolution video / photo with detail flying over the whole incident scenery may give investigators the chance to find a proof that may not be seen at the first day of the investigation.

One important mission to perform that can really help in the investigation is getting a 3D or 2D model of the area. In order to capture as many details as possible during the flight:

- Choose the best camera (number of Mpx)
- Fly low
- Fly steady
- Fly slow
- Choose the best sunshine conditions (if planned flight)

All this information may direct a fire investigation by showing new trails to follow in the investigation and can even be used as proof in situations of criminal charges, insurance claims and other processes that are related to the specific fire.

D. FIRE PREVENTION / CODE ENFORCEMENT TECHNIQUES

There are many aspects of fire prevention and code enforcement where the use of a drone can provide benefit. Generally speaking the more area or detail by which any inspection site or premise can be visualized the greater the opportunity to realize and address code violations or hazardous conditions. A drone provide for time and personnel efficiency in covering larger areas or sites which previously would not have been accessible for inspection or would have required personnel and resources beyond what many agencies could commit to the process. Examples of this can include:

Conducting pre-fire compliance inspections at wild land - urban interface properties

Traditionally it was necessary to inspection personnel to physically walk the perimeter of structures and evaluate brush and vegetation conditions to make recommendations or compliance referrals to the property owner. Often these interface areas are not vehicle accessible and in order to conduct thorough or complete perimeter inspections the inspection teams would invest significant time resources to make the inspections.

With a drone a team of perhaps 2-3 inspectors could setup at a central location and conduct flights over the area to survey the interface much more efficiently and effectively while not exposing personnel to natural hazards (falls, animal encounters, poisonous dishes). The records of the inspection can be easily captured using the drone camera and cataloged to develop historical data on changes which would otherwise not be recognized from ground level.

If the agency developed pre-flight planning then in the future semi-autonomous flights could be conducted and transmitted to a remote location for review by inspection personnel, further reducing the time investment by personnel on the ground. This could prove valuable such that flights could be conducted and the data simply saved for later compliance review. In this mode of operation the flights can maximize flight time and rapidly document a large area without needing to simultaneously review and evaluate footage in the field.

Some inspections may expose inspection personnel to hazards inherent to the operation or occupancy. Through the use of drones the inspection personnel can locate themselves out of the hazard area but still have visual inspection capability. Examples of this can include:

Inspection of roof top photovoltaic installations

Many times the only areas available for personnel to walk the roofs of PV installations are dedicated aisles and open spaces along the roof edge. Walking in these locations could present hazard and use of fall protection equipment may indeed improve safety while slowing the overall inspection process to a point where it becomes too cumbersome. Drones can be deployed to fly above the roof and equipment in question and through the use of better quality camera optics and zoom lenses the inspection personnel can view the video feed remotely or on the ground with enough detail and clarity to perform a subjective inspection but while not being exposed to the trip & fall hazards associated with walking along the edges of flat or sloped roofs. Further, the use of thermal imaging capable drones would allow inspection personnel to quickly inspect existing installations for signs of spot heating or unusual temperatures which may indicate early faulting equipment or impending failure of cables / conduits.

Another example of time efficient visual compliance inspections would be **to conduct flights over eating & drinking establishments** to visually check that commercial cooking systems are being properly maintained and are not excessively full of grease that is spilling or flowing on the rooftop.

Traditionally, these types of inspection would require accessing the individual roofs of each business to visually check cooking exhaust equipment. Depending on site specifics this may mean using a fixed ladder or committing a ladder company apparatus and crew which makes the evolution an inefficient use of crews and resources, no matter how necessary the work may be.

The drone could be easily deployed by a crew of 1-2 fire fighters or inspectors who are able to fly to multiple sites and visually check them all from a central location such as a parking lot surrounding clustered food establishments.

This significantly improves the overall efficiency of the evolution while freeing up time for other activities or to continue more inspections. The results of the inspection can be captured using the camera equipment for recordkeeping beyond just observing the live feeds.

While conducting **periodic inspections** of large buildings or large building sites a drone should also be deployed to gather site photographs for comparison to prior inspections or previously approved site plans. These comparisons can show whether prior approvals for fire apparatus access, outside storage limitations, and hazardous materials areas are all being properly maintained.

In addition these historical photos can show if unauthorized construction or changes may be taking place on the site over a period of time. This is particularly useful with large open sites such as waste yards, recycling facilities, auto salvage, forestry processing, and surface mines.

It would not be unheard of for such occupancies to push their limits or expand beyond original boundaries over the course of time. This is especially likely when public view of the property is limited from the street and surrounding areas are undeveloped and unoccupied. Without aerial over flights and persistent photo comparison it is fairly easy for conditions at such sites to grow and 'creep' outward for many years, often only coming to attention of regulatory personnel after a problem occurs and brings the unwanted attention.

E. FLOOD MANAGEMENT TECHNIQUES

An overflow of water that submerges land that's usually dry is considered a flood and may endanger persons, animals and structures. There are several types of floods being the most common flash floods, river floods, coastal floods and they may affect infrastructures in several ways, even by causing collapses.

There are several particularities that rescuers most take into account when performing rescues in a flood, such as:

- Water speed, strength and height;
- Flood extension;
- Objects dragged;
- Electric risk (broken power lines);
- Pollution and contaminated waters;
- Underwater traps (such as nets and holes);
- Strategy to implement.

Using drones in emergencies is a major advantage since they can undertake several types of missions in this type of situations, missions that could be:

DURING THE RECOGNITION PHASE

During this initial phase, attention is paid to the presence of victims to be saved or to recover but also on taking into account the surface area of the area affected by the flooding.
The risks associated with flooding will also have to be identified (strong current, suction manhole covers, electricity).

In order to carry out these missions, the following techniques may be useful:

Mapping Technique:

- Map the affected area;
- Localize access
- Localize people on roofs
- Delineate flooded area, including boat access areas;
- Count isolated dwellings

Coordinated Overwatch Maneuver:

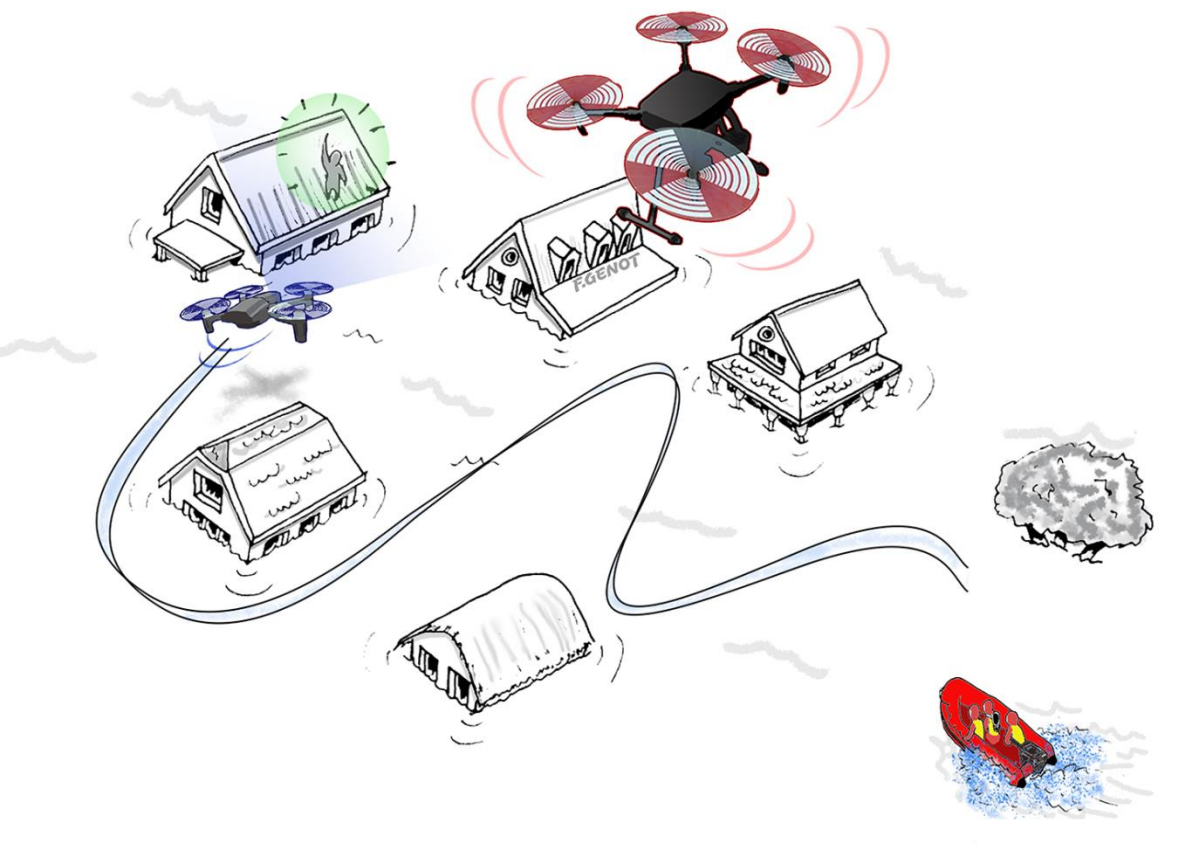
- Combine recon & situation awareness for commander

Live Streaming video Technique:

- Live situation awareness for commander and ops center

Aerial Escort Technique:

- Monitor water rescue teams in their progression

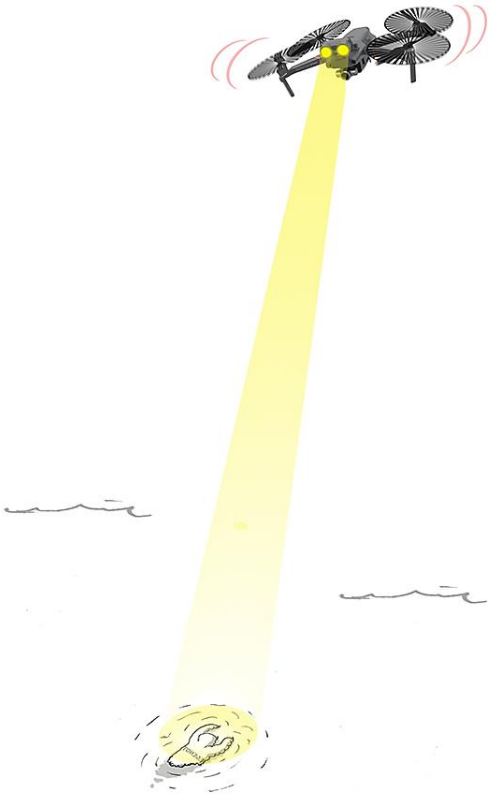


DURING THE RESCUE PHASE

The following techniques can be implemented work to locate, "to mark", to reassure and to come to the aid of flood victims:

Sensitive Points Search Technique:

- Locate victims with thermal camera



Victim Designation Technique

- Designate victims in hovering or lighting
- Guide water rescue teams

Dropping Technique:

- Deliver rope to perform rescues ;
- Drop life vest or raft to help victims;
- Drop supplies to rescuer or victims;

Sound Broadcasting Technique:

- Communicate with victims;
- Reassure and inform victims

F. COLLAPSES OF STRUCTURES TECHNIQUES

Structures may collapse from natural catastrophes or man-made disasters such as earthquakes, explosions, landslides and many others. Collapsed building search and rescue is extremely difficult and very time-consuming. A partially collapsed building can be simply too dangerous to enter directly depending on the remaining stability.

Depending on the cause and its extension, the collapse of a building can be partial or total, but in extreme cases, it can affect an entire city as in 2021 in Norway after a landslide or in 2020 in Lebanon after the explosion in Beirut.

Norway, village of Ask, a 2000 feet long quick clay landslide

Photo courtesy of Anders Martinsen, UAV Norway

In this type of situations there several risks that should be taken into account as:

- Instability in the area and in the damaged structures may cause more collapses ;
- Residual electrical risk
- Hazmat materials may escape containments;

All data (images and accurate information) on the affected area are able to assist the Incident Commander. By continuously increasing situational awareness, it is decisions that are faster and more efficient. But it is also a reaction, a faster progression of teams in difficult environments.

Among the many buildings collapsed during an earthquake, fast and agile drones can help in choosing the building where there are chances of saving victims. The drone can enter small spaces where research would be too dangerous for humans. He can locate the victims inside the building and make a

rough assessment of the victim's condition. In this situation, a small drone with a protective cage (in indoor configuration) seems the best solution for interior reconnaissance.

Because of the collapse of the structure and the debris, the risk of losing the video of the drone is quite strong. A relevant configuration of the fail-safe system is essential (to avoid a return home). Dangers exist in these interior explorations, such as exposed wires that can be difficult to see on a video, dust in suspension that can possibly reflect the light of the drone making it almost blind.

When a drone team is deployed, it can be used:

- To search for victims with thermal camera (see the paragraph **5-A SAR techniques** and also **the indoor technique**)
- To collect imagery intelligence to evaluate the stability of the building (**spiral technique**) or the better access to it.
- To map the affected area to determine the most affected structures, and even give detailed images of critical points (**mapping technique**)
- To transport supplies (medical supplies, gear, batteries, radios, smartphones, food) that are needed in the several sites from the logistics area (**dropping technique**)

Photo Courtesy of North Texas PSURT team, two cranes collision

G. ECBRN TECHNIQUES / HAZARDOUS MATERIALS

ECBRN or Hazmat operations are complex operations with major risks.

ECBRN risks are linked to:

- an unconventional practice of armed combat;
- Use of weapons with contamination capabilities (terrorism);
- Accident or disaster (transportation of dangerous goods)

If a drone team is to intervene in the context of an NRBC operation, it must first become aware of the specific typology of the present risk (briefing of the incident order or an advisor ECBRN / HazMat) . These risks can be:

- Explosion (industrial incident)
- Cylinders involved in fire
- ECBRN explosion (terrorist attack)
- Chemicals (industrial or transport incident)
- Radiation (industrial or transport incident)

Often what would take several hours could be done in a few minutes using a drone pilot.

1. HAZMAT INCIDENT TECHNICS

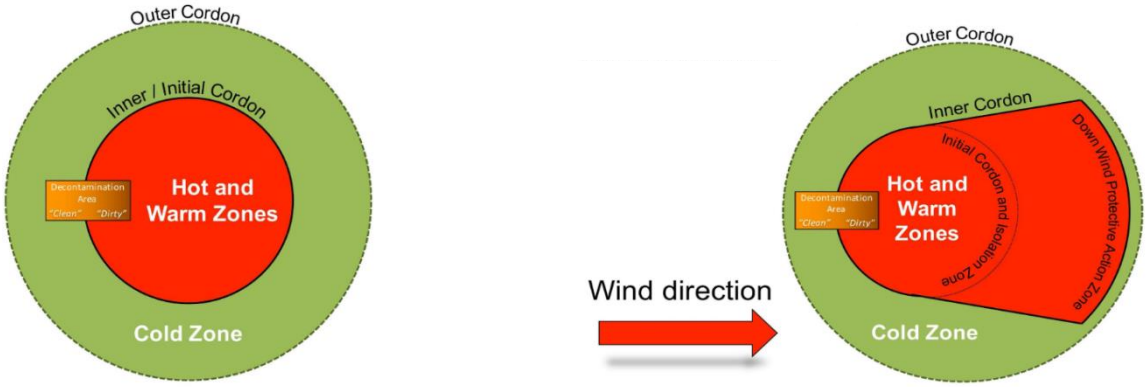
Regarding the first HazMat teams, during the dressing (protective clothing) no recognition is possible.

In addition, the air supply lasts about 30 minutes, which breaks down into 10 minutes for the outward journey, 10 minutes for capturing measurements and looking for victims and 10 minutes for the return on foot.

Because of this constraint, HazMat teams must enter several times, not only by losing time, but also by exposing themselves even more.

While with a drone in reconnaissance, during and after the dressing phase, teams can get a detailed vision of the path and the site. But also getting tools dropped off at the right place before arriving. This saves several hours of operation, and therefore saves lives.

The drone team should never be in a hot zone. From the basic principle of the drone: operating remotely, exposing a drone crew to an ECBRN risk makes no sense.



The choice of TOLA must be made wisely so as not to be exposed by toxic fumes. The TOLA must therefore not be placed in the upwind direction. For this reason, the drone must keep a safe distance to avoid being contaminated.

Concerning the risk of explosion caused by a spark, for a long time many thought that the drone could trigger an explosion by the emission of a spark.

The Southern Manatee Fire Rescue conducted 3 flammability tests on 3 different drones in a hermetically sealed container to determine if a drone would ignite a flammable propane-based atmosphere. The results where that the drones didn't cause an explosion within the container whilst the motors where being run (video is online)

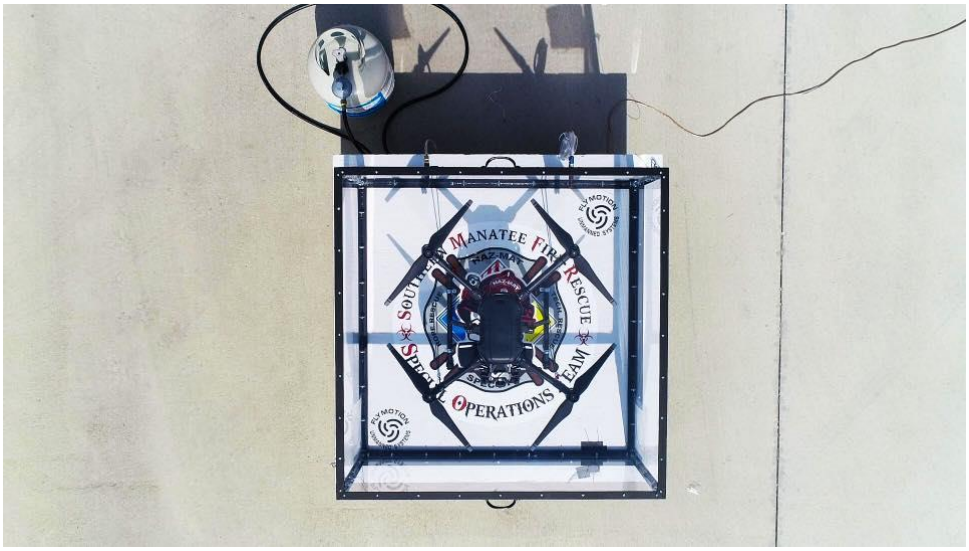


Photo courtesy of Southern Manatee Fire Rescue

They then tested how much damage would be cause by a drone within an explosion, and ignited the gasses. They were surprised when only light damaged was caused, and after a few repairs were able to successfully fly it again.

Now the certainty of an explosion by a drone spark is much less likely especially in the open air.

TECHNICAL TIPS

Configure your drone as detection tool is possible. We can strap a Detection Monitor to a leg or chassis, and do basic sampling to keep firefighters out of the danger zone.

Photo courtesies of Southern Manatee Fire Rescue

The in-flight measurement technique

So this technique is to fly while doing measurements, but not to measure the amount of product in ppm, but just to detect the presence of the product. And these in order to better adapt the zoning of the incident (hot, warm and cold areas).

Photo courtesy of Southern Manatee Fire Rescue

The post-landing measurement technique

It's not always necessary to fly to do measurement, a good example is to land a drone into a hot zone, cut power and use the monitor to sample the area without the disruption of the rotor blades. And then it can be moved about the incident, giving various readings for the incident commander and HazMat teams to work with.

Photo courtesy of Southern Manatee Fire Rescue

2. AQUATIC POLLUTION TECHNICS

Pollution of Aquatic systems (Examples: lakes, rivers and oceans) by large amounts of waste material that modify the water in negative fashion is termed as Aquatic Pollution. This type of ecological deprivation occurs when harmful pollutants are directly or indirectly discharged into aquatic systems without removal of harmful compounds.

Aquatic pollution directly leads to suffering of organisms and vegetation that survive in water, including amphibians. The main source of Aquatic pollution include Industrial waste, Mining activities, Sewage and waste water, Marine dumping, Burning of fossil fuels, Accidental Oil leakage, Urban development etc.

A drone team can de deploy to an aquatic pollution (mainly on rivers).

The main task is to evaluate and estimate the dimensions, the surface area of visible pollution. Then the next mission is to locate the source of the pollution if it is not known.

If the pollution is in urban areas, it will be necessary to fly mainly over the river. A linear recognition makes it possible to measure the length of the pollution either by the geometric evaluation technique or directly with an integrated rangefinder.

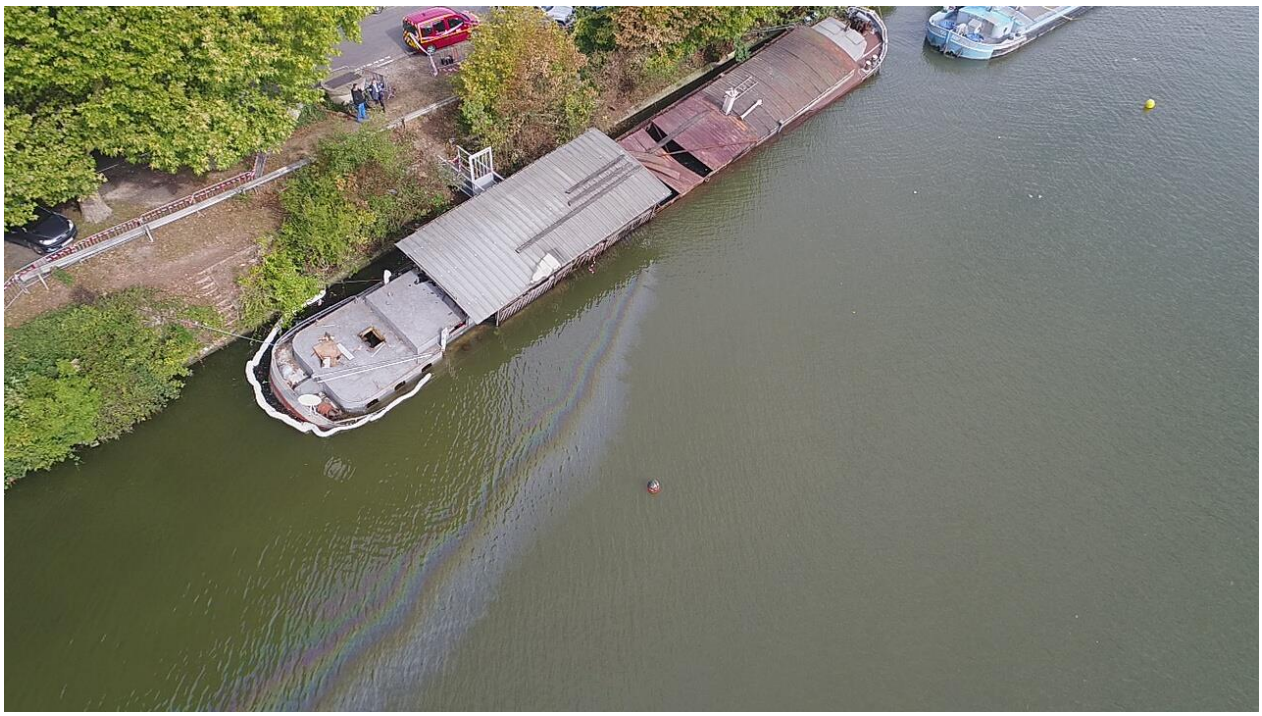


Photo courtesy of SDIS 67

To locate the origin of the pollution, it is necessary to go upstream in search of the origin of the pollutant (fuel degassing from a boat, accidental or voluntary leak from an industry,…). Be careful to respect the rules and laws of your country for BVLOS flights.

Photo courtesy of SDIS 67

The drone team can also be used to assess the effectiveness of an anti-pollution barrier. A vertical visualization of the installed dam makes it possible to evaluate and quantify its effectiveness (**technique of evaluation of actions**).

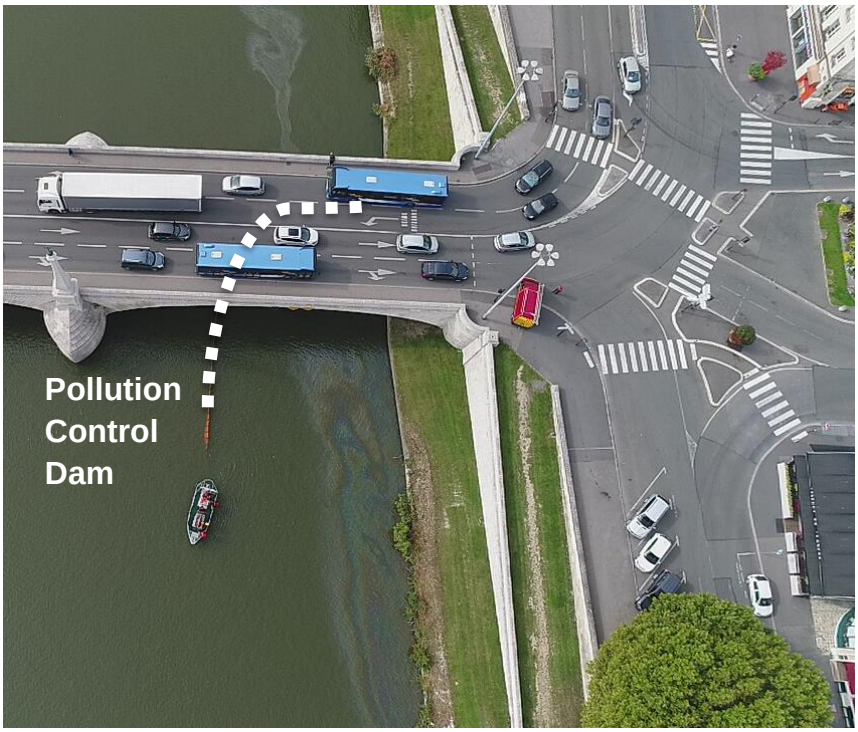


Photo courtesy of SDIS 60

8. TECHNOLOGIES TO BE DEVELOPED

The technology around the field of the drone is evolving at an increasing speed. Developments and revolutions are cyclical, innovations disrupt the drone market every 6 months.

The technological expectations of rescue and firefighting services are both basic and sharp.

The basic needs are focused on an evolution, an improvement of the systems used today. More flight autonomy, more waterproofing, more performance on optical and thermal sensors, more interconnections to share, but also an upgrade of drones on lighting and sound broadcasting capacities.

The specific and sharp needs relate to the development of applications linked to artificial intelligence to accelerate the analysis of the image where the eye can be slow and tired. But also on fixed-wing drones or VTOLs, long elongations for large-scale mapping. The development of radiological and chemical sensors with integrated telemetry. Augmented reality or 3D modeling software is not left out, there is also a lot to improve in the accounting of drones on the market and the speed of heavy computer processing.
The automation of drone swarms will undoubtedly happen one day, but first it would be interesting not to rush at the risk of not strengthening the foundations of today's uses.

The drone is only an aerial vehicle onto which we can graft all the technological bricks we want.

9. CONCLUSION

All the knowledge and techniques in this report, which was collected in 13 countries, is not exhaustive. There are certainly many other tips and techniques around the world. If this report helps at least one person, IEDO have done his job.

The mission of IEDO is to increase the knowledge of each of its members through sharing and exchange. The aim is to make these emergency drone pilots better and more efficient, but also by giving them the desire to develop, optimize and sustain greater operational capacities by following the innovative evolution of tomorrow's technology.

We are confident in the future, we are sure that many other first responders using drones will join the IEDO association to share their knowledge. And perhaps expand the working groups that will work now on the second edition of this best practices report scheduled for the end of 2021.

Sharing, exchanging, learning and improving are the pillars of IEDO to unite and expand a community of drone specialists all gathered around a mission: saving more lives with drones.

Fly safe

10. TECHNICAL ANNEXES

ANNEX 1	DRONE	DJI M300 RTK
ANNEX 2	ACCESSORY & SYSTEM	Excelerate UAV Streamer
ANNEX 3	SOFTWARE	Pix4DReact fast-mapping

ANNEXE 1

DRONE

MATRICE 300 RTK

Thermal Drone Solution

WATCH NOW

A New Standard for the Commercial Drone Industry

The Matrice 300 RTK is DJI's latest commercial drone platform that takes inspiration from modern aviation systems. Offering up to 55 minutes of flight time, advanced AI capabilities, 6 Directional Sensing & Positioning and more, the M300 RTK sets a whole new standard by combining intelligence with high-performance and unrivaled reliability.

- 15 km Max Transmission[1]
- 55-min Max Flight Time[2]
- 6 Directional Sensing & Positioning
- Primary Flight Display
- IP45 Rating
- -20°C to 50°C Operating Temperature
- Hot-swappable Battery
- UAV Health Management System

[1] Unobstructed, free of interference, when FCC compliant. Maximum flight range specification is a proxy for radio link strength and resilience. Always fly your drone within visual line of sight unless otherwise permitted.

[2] Actual flight time may vary because of the environment and payload configurations.

ANNEXE 2

ACCESSORY & SYSTEM

REAL-TIME DRONE FOOTAGE BEYOND THE PILOT

When using drone technology, real-time footage isn't always accessible beyond the pilot. Excelerate's UAV Streamer resolves this problem by making live video streams more accessible. By simply plugging the solution in to your existing UAV system, live footage is streamed over public or private networks securely via Excelerate's ExStream Video Application. Footage can then be accessed securely anywhere via any authorised device with an internet connection.

Simple and secure Just plug and play

- Plug your UAV controller in to the UAV Streamer solution via a HDMI cable
- Access footage from any authorised device whether desktop or mobile or on a vehicle via the ExStream video application
- Stream real-time footage to any authorised location via 3G/4G
- Control and manage streaming to multiple user groups

Footage streamed through ExStream is fully encrypted to provide the highest level of protection for our customers.

Excelerate's UAV Streamer and ExStream Video Application is currently in use by a number of Emergency Services and Special Operations across the globe.

For a full specification +44 (0)845 65 85 747 **or visit our website**

ANNEXE 3

SOFTWARE

PIX4D

Pix4Dreact

2D fast-mapping for emergency response and public safety

Get rapid and reliable situational awareness from drone images in minutes

Try for free at **pix4d.com**