Drones in public safety:

the bigger picture

March 2021

Public safety is a varied and complex industry. This is because no two cases are ever the same - whether it is a fire, a search and rescue mission or a vehicle crash, public safety operations are always unpredictable. Some techniques in use are ancient, like clearing undergrowth to prevent wildfires, whereas others, like using thermal imaging to find missing people, are more modern. This is where drones and mapping technology can help.

Why use drone mapping?

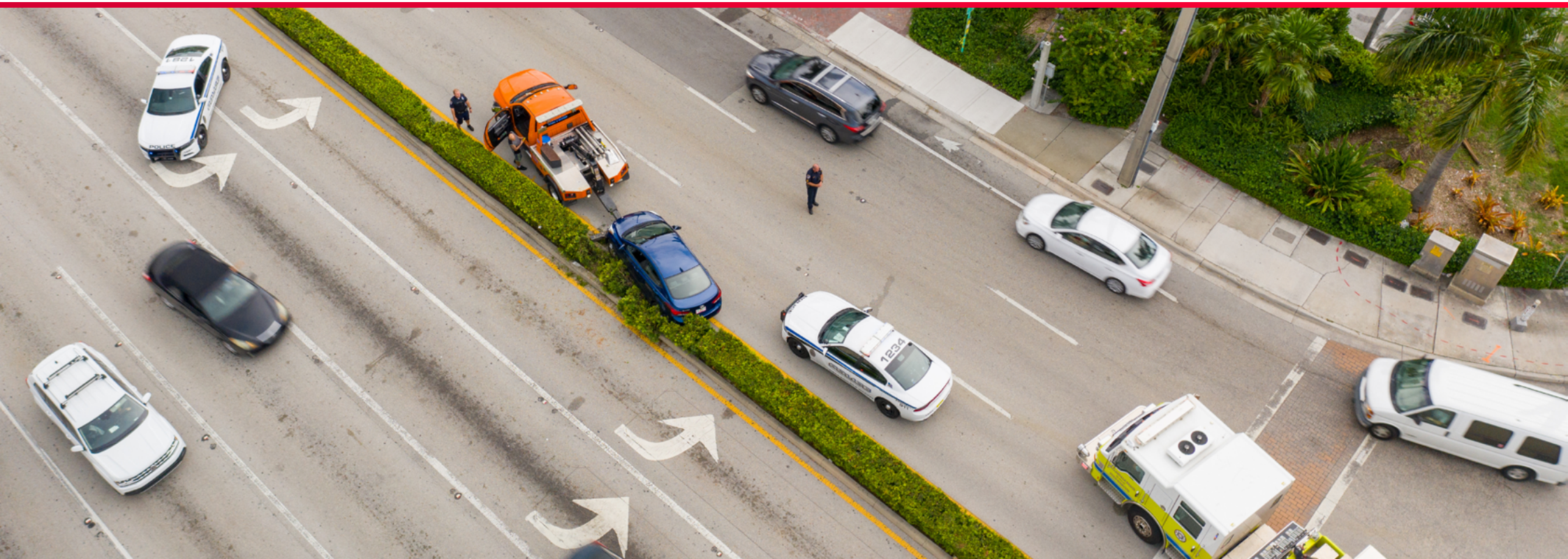
Drones can see the bigger picture - literally. They can access remote locations, use specialized cameras to penetrate vegetation, gather details missed by people and access wide areas faster than teams on foot.

It's not just about drones, but the software that comes with them.

Photogrammetry, or measuring from images, can help generate models and maps, measure distances, as well as calculate volumes of spaces.

This mass data collection can help in gathering information about a site for an emergency response or disaster preparedness, which in turn saves lives and costs. The data is used alongside the work of people in the field, as well as other equipment such as LiDAR or thermal imagery cameras.

The technology around drones is rapidly evolving, revolutionizing the sector. Search and rescue in particular is a specific area with quick uptake in using drones to look for missing or injured people. As drones and software can be connected to the internet, cloud platforms can now be used to share maps and pool information and expertise from around the world in no time.



Contents

This eBook aims to explore and explain how drones can help with public safety in a few key areas.

In addition to explaining how drones can be used in these sectors, chapters will include examples of organizations already using them in their public safety operations, tips for best practices and ideas for including drones in your workflow.

Drones and UAVs can make a huge difference in saving lives, either through preventative action or in response to an event. A more widespread adoption relies on information - of how effective working with drones can be, how fast, and how they can be integrated with existing workflows.

> "Drones and UAVs can make a huge difference in saving lives"

PIX4D

01

Drones for emergency responses with fires

This chapter focuses specifically on fires and emergency response. There are several key uses of drones and photogrammetry for managing and responding to fires, differing according to whether it is a wildfire or an urban fire.

Key applications

- Predicting wildfires
- Tracking and slowing the spread
- Wildfire recovery

Benefits of drones

- Gathering information to assess the blaze
- Helping plan strategic responses
- Assessing the damage in unstable structures
- Helping in fire investigations

With a focus on wildfires in this chapter, the next pages include use cases about predicting, responding to and tracking fires as well as wildfire recovery efforts. They also include a recommended workflow on using drones for live-fire response and investigation.

Wildfires pose several challenges to emergency response and public safety. Here are some key details to be aware of:

- Wildfires can be spurred on by weather, and change direction unpredictably.
- They can be caused by both people and nature.
- It is a natural cycle exacerbated by the climate emergency.
- They can be mitigated with forest and shrub management to avoid too much dead vegetation on the ground.

Software to help solve problems

- Pix4D**react**
- Pix4D**mapper**
- Pix4D**cloud**
- Pix4D**capture**

With photogrammetry software, the results can easily be examined and annotated, marking points of interest such as buildings at risk or potential fire accelerants and obstructions. This can then be exported to other teams so decision-markers can get resources to where they will be most effective.

Predicting wildfires

Understanding how a wildfire may move can help get resources in place in time and warn residents in vulnerable areas. Not everyone has the infrastructure to set up an extensive fire-prevention plan, but drones can help save time and costs. High-quality images gathered by drones are uploaded into the appropriate software to create maps that can be used to assign ground clearance teams or inspectors to different locations.

USE CASE

Predicting wildfires in California

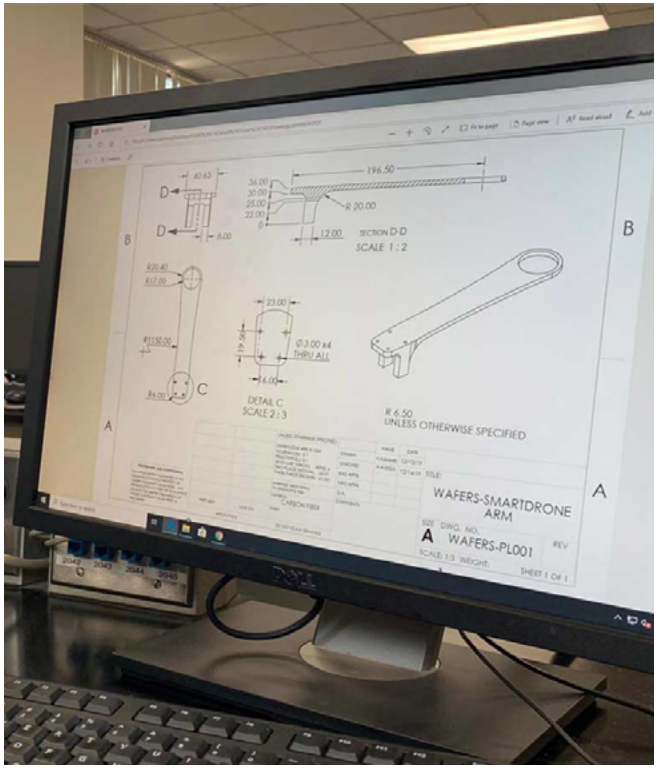
The Wildfire Aversion by Forecast and Early Response System (WAFERS) work on predicting wildfires in California, USA. The team is led by Abdulmohsen Aleissa and won 2nd place in the Pix4D Climate Contest in 2019. They track wildfires using thermal and RGB drone maps to predict their spread, which can help prevent them in the first place.

LOCATION
California, USA

SOFTWARE
Pix4Dreact, Pix4Dmapper

HARDWARE
Custom-made drone,
FLIR Duo Pro R for RGB,
Microsoft Surface laptop

PROCESSING TIME
1 - 2 minutes (less than 10 acres), 4 - 5 minutes (40 acre fires)



The WAFERS team wanted to help wildfire management by being proactive rather than reactive. It's not just about halting the spread of current fires but proactively assess potential, imminent fires.

Wildfires can cover 60km (37 mi) in 1 day. Current wildfire spread simulations, such as those run on supercomputers, can take up to 3 days to run. Conventional methods for assessing fires, like satellite imagery, helicopter or aircraft, can be significantly more expensive, slower, and use labor-intensive workflows.

Benefits of using drone mapping for the WAFERS team

- Predict fires
- Reduce costs
- Reduce climate impact
- Accuracy

How does WAFERS work?

The WAFERS system used a custom-made rotary drone equipped with RGB and thermal cameras. The rotary drone is good for short flights over rugged terrain. Rotary drones can also be launched from anywhere and land in smaller spaces than fixed-wing alternatives.

The workflow:

1. Collect data.
2. Import into Pix4Dmapper to generate a thermal map to check for hot spots.
3. Fire is detected. WAFERS's specialized algorithm automatically simulates the fire's spread with a 'what-if' analysis.
4. Use Pix4Dreact to generate an orthomosaic for estimating the wildfire spread pattern.
5. Cross-reference with weather forecasting data.

The WAFERS team is there to support the needs of first responders. They can work on-site and offline to avoid communication barriers that spring up when first responders need to coordinate with an office far away. This in-the-field availability allows first responders to act faster and safer.

Key takeaways

- Use the elements of the software as best you can.
- Adapt to suit your workflow.
- Learn and optimize over time.

Tracking wildfires (and lava!)

Once a wildfire breaks out, the aim is to predict it and prevent it from getting worse. This requires regular, up-to-date information about the wildfire at all times.

The algorithms used by WAFERS can be very helpful in understanding the path the fire may take, but it needs to be consolidated with live information to see if there are any shifts.

The key element of photogrammetry for tracking an emergency is gathering information quickly, with accurate, safe methods that help inform decisions to do with evacuation routes, deployment of resources and public awareness.

Appropriate software

- Pix4D**react**
- Pix4D**mapper**
- Pix4D**capture**

USE CASE

Mapping lava

In May 2019, the Kilauea volcano erupted in Hawaii. It opened over 10 lava fissures on the Big Island and triggered an earthquake. A team from the University of Hawaii at Hilo (UH Hilo), led by Dr. Ryan Perroy, prepared to map the lava flow to help mitigate the disaster. Their assistance was requested by the Civil Defense authorities. They were supported by Frontier Precision, who sent specialist Dr. Nathan Stephenson, who had mapped lava flows in Hawaii previously during a 2014 eruption.

LOCATION
Puna, Hawaii
United States

SOFTWARE
Pix4Dmapper

HARDWARE
DJI Matrice 200,
Inspire 1, Inspire 2

PROCESSING TIME
15 - 20 minutes
[rapid processing mode]

The heat from lava fissures can reach 1,200 °C (2192 °F). Dr. Perroy and the UH Hilo Spatial Data Analysis & Visualization (SDAV) research lab were asked to map the lava fissures to assess the threat to infrastructure, roads, and houses in the Lower East Rift Zone.

The team flew drones both day and night to keep track of the lava. The airspace had been cleared to non-essential traffic, enabling the team to fly without fear of causing unpredictable aerial hazards. They flew at 305 meters (1000 feet), with special dispensation from the FAA. Higher altitudes require fewer images for capture, and thus, data processing can take place sooner.

> "One thing we have now that we didn't have in 2014 was a thermal radiometric camera that helps us map more accurately at night and enables us to capture large heat signatures"
>
> **– Nathan Stephenson, PhD**

Main area of risk:
Section of highway

Reason:
Important evacuation route

Observations:
Road cracked and emitted steam, but the fissure did not fully erupt and the road remained open to traffic with cracks bridged by thick, steel plates.

Applied Pix4Dmapper features:

- Rapid processing mode meant results in 20 minutes. Less accurate, but enough detail. Could see if lava moved, and measure how far.
- Ground control points were not always reliable - needed to predict the flow of lava, which was not always possible. GCPs could also be swallowed by the lava.
- Earthquakes meant the landscape moved, disrupting GCPs.

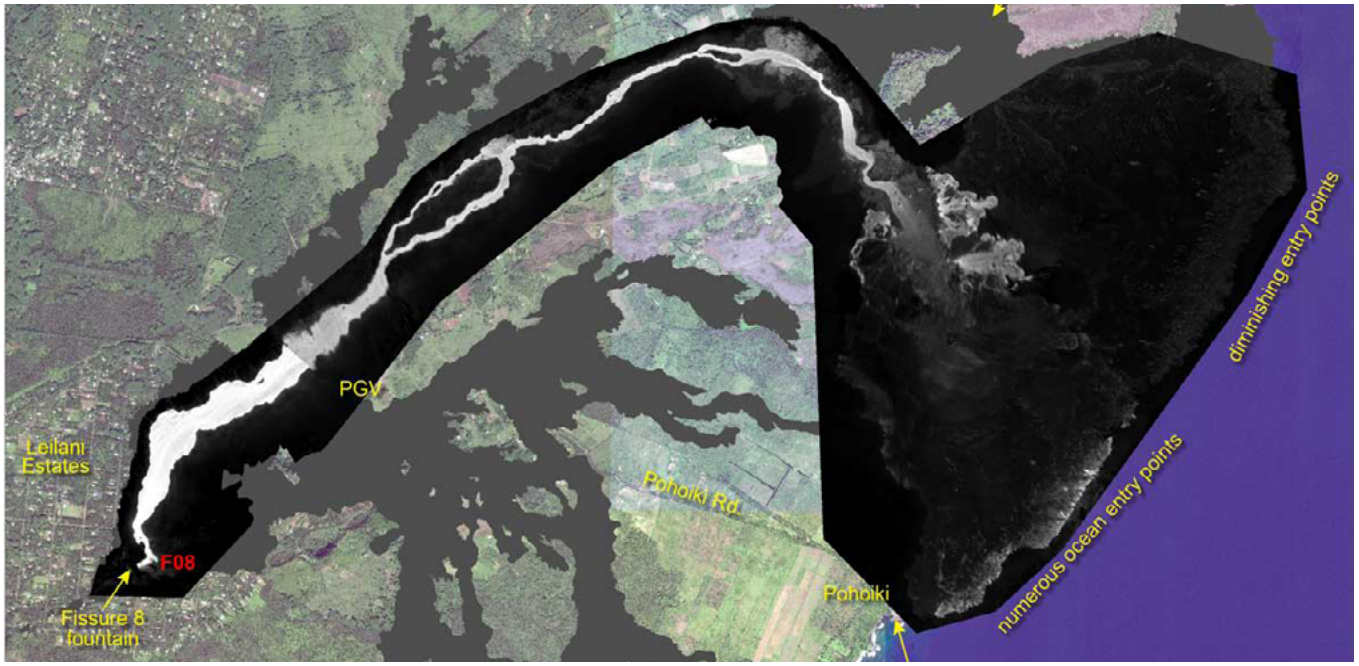
They used a Wi-Fi hotspot to share results via DropBox, sending them directly to the emergency management teams made up of the USGS, Civil Defense, the Fire Department, and the Mayor's office.

The lava sometimes moved 30 meters (100 feet) in an hour, so the live updates were critical to staying ahead of the damage. The team overlaid orthomosaics over base maps and country road maps, stacking them to show the changing position of the lava over time.

Total time scale:
4 months, 7 days a week

Key takeaways

- Fast mapping was critical to acting effectively.
- Team safety is vital in unpredictable situations.
- Sharing results online can mobilize resources faster.
- Drones can be effective at tracking fires and other fast-moving heat sources.



Disaster recovery

Finally, there comes wildfire recovery with drones. The sheer amount of damage wildfires can do to both the environment and infrastructure is huge. Once again, photogrammetry can help with this. Software can measure distances and estimate volumes of materials. This informs authorities about the scale of damage or large objects that may need to be moved.

Appropriate software

- Pix4D**react**
  (2D maps and orthomosaics)
- Pix4D**mapper**
  (volume calculations, 3D models)
- Pix4D**capture**
  (flight planning automation)

USE CASE

California wildfire response

Dr. Greg Crutsinger, working with GeoAcuity, helped map a damaged area before residents returned. There was high time pressure, as evacuated people wanted to get back to their homes. The terrain was difficult to navigate, so teams split up the surveying area into manageable chunks. This division of labor sped up the whole process of data collection.

LOCATION
Boulder Creek, California, USA

SOFTWARE
Pix4Dreact

TOTAL IMAGES
+ 10,000

GSD
0.7 - 1.5 in

AREA MAPPED
6,000 acres (24 km²)

PROJECT TIME
48-hour turnaround

HARDWARE
Phantom 4 Pro, Mavic 2, Mavic Enterprise, Wingtra One

Workflow:

1. Teams sent out for data collection.
2. Teams return with data.
3. Data processed in 20 minutes.
4. Results inspected, checked for issues.
5. Team reassigned to a new area, results shared as a GeoTIFF.

Pix4Dreact benefits

- Fast processing
- Stitch together different areas as results came in
- Easy to inspect
- Easy to export
- Export in GeoTiff

Key outcomes

- Interactive before/after map used in comparison with satellite imagery.
- Searchable by address.
- Residents get a full understanding of the path of fire and damage to property.
- Property lines added and annotated.
- Effective record of fire damage.

COMPARATIVE USE CASE

Australian wildfire recovery

The FRNSW Bushfire and Aviation Unit works on: flood response, hazmat incidents, supporting bushfire operations, subterranean fire monitoring, post-incident disaster assistance recovery, volumetric calculation of debris. They helped assess damage after the Australian wildfires of 2019/2020.

The purpose of the project was to estimate the volume of debris using remotely piloted aircraft systems on both an individual property level and overall quantity in communities across the state.

SOFTWARE
Pix4Dmapper, Pix4Dcapture

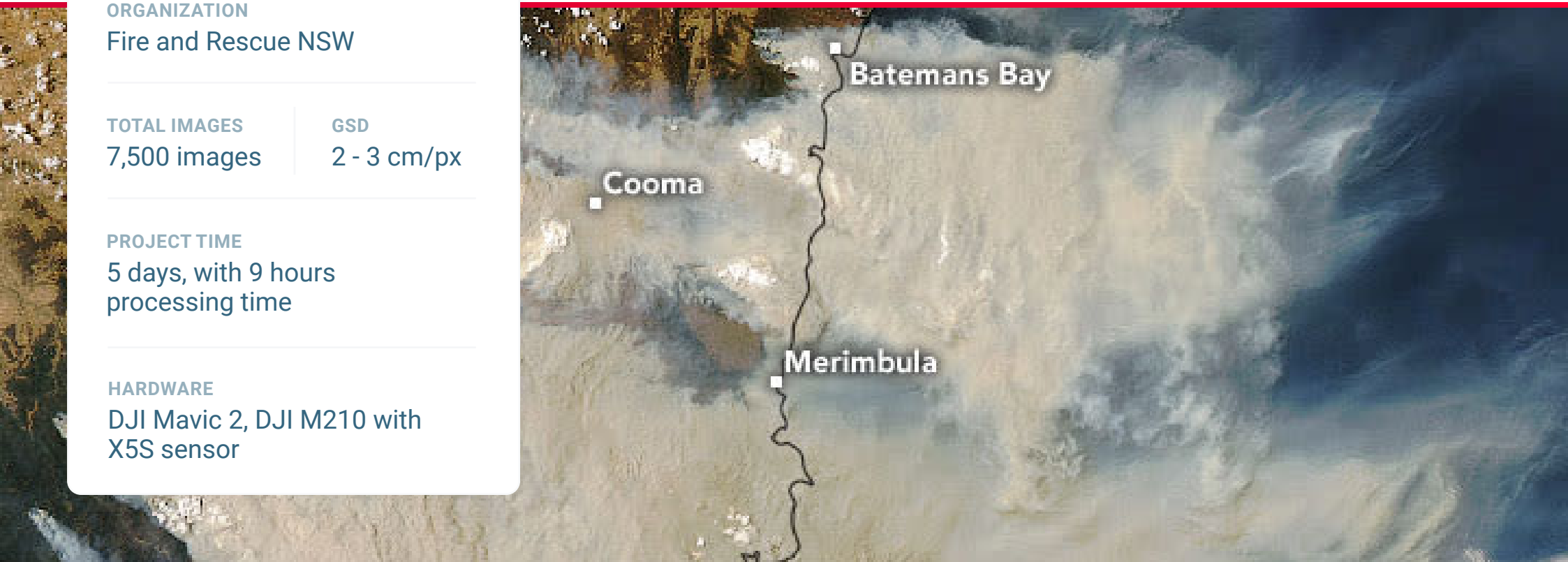
ORGANIZATION
Fire and Rescue NSW

TOTAL IMAGES
7,500 images

GSD
2 - 3 cm/px

PROJECT TIME
5 days, with 9 hours processing time

HARDWARE
DJI Mavic 2, DJI M210 with X5S sensor



The Australian wildfire season of 2019-2020 was extreme, with 33 people killed including 9 firefighters. 67% of the state of NSW burned - 5.3 million hectares (13 million acres). Almost 2,500 homes were lost in NSW, which left behind significant waste. Some of this, such as asbestos, could be harmful. It needed to be carfully cataloged by the FRNSW Bushfire and Aviation Unit.

The organizational technique was to categorize waste:

- Green waste (organic)
- Recoverable materials
- Vehicles and equipment
- Building waste
- Asbestos waste
- Hazardous waste

Key takeaways

The important job here is informing waste management agencies of what they will be faced with so they can understand what they will be dealing with, and how much.

Structural fires and drones

Drones can help respond to fires, as well as prevent or recover from them. They save time, help plan efficient deployment of equipment, and give a bigger picture of what is happening. This is relevant to urban fires too.

USE CASE

Warehouse fire and damage assessment

The Yvelines Fire Department responded to a warehouse fire in the summer of 2020. They were on this site twice: firstly during the live fire, and afterwards to help with assessing the damage for the investigation.

LOCATION
Yvelines, France

SOFTWARE
Pix4Dreact

TOTAL IMAGES
108 for fire, 39 for investigation

PROCESSING TIME
6 minutes for fire, 8 minutes for investigation

AREA SURVEYED
594 m² (710 yards²) for fire, 552 m² (660 yards²) for investigation

Live fire response workflow

1. Set up a cordoned-off area for drone pilots. Members of the public or other firefighters can be a distraction.
2. A partner and a pilot will work together to ensure the drone flies safely. The pilot will coordinate with the Incident Commander, look for ground obstacles, and analyze the feed coming from the drone. The partner maintains a visual line of sight with the drone and takes charge of aerial safety, including communicating with local air force control.
3. Process the data on Pix4Dreact in the field on a standard administrative laptop to render results in under 10 minutes.

The drone provided thermal imaging to give information about the fire intensity to the Incident Commander. The drone pilots returned to the site several months later to gather data for a fire investigation. For this, they generated another 2D map that investigators could use to measure distances and visually inspect the damage before entering the building.

02

Environmental and disaster risks reduction and response

Public safety is not just about responding to unexpected events, but also mitigating and preparing for them. With the continued escalation of the climate crisis, preparing for climate-triggered events is becoming more important than ever before. Communities around the world are increasingly vulnerable to climate change and the impact on human lives and the local and global economy keeps on growing. Understanding and predicting these natural phenomena like fires, floods, landslides, drought, or cyclones to protect vulnerable populations allows governments, the local community, and NGOs, to implement disaster risk reduction measures to limit the impact of these events.

In this context, using mobile high-resolution cameras like drones and handheld devices can help prepare for an unpredictable future. Working with the right software to capture essential insights, interpret and disseminate the data helps public safety operators meet these challenges to protect and save lives and reduce costs.

Benefits of using drones

- Site assessment and rapid damage evaluation
- Volume calculations for large landmasses
- Creating accurate models of unstable structures
- Easily share collected data with relevant authorities
- Have up-to-date records of shifting landscapes or recovery efforts

Climate-related public safety management includes two key areas:

Recommended software

- Pix4D**capture**
- Pix4D**react**
- Pix4D**mapper**
- Pix4D**fields**
- Pix4D**cloud**

1. Preparation

Preparedness saves time, which in turn saves lives. Some events that can be prepared for using solutions like warning systems, environment monitoring, and raising public awareness. Drones can help with monitoring an area, inspecting hazards, and assessing risk points in otherwise inaccessible areas.

2. Response

When an event occurs, the priority is a fast response that is based on well-informed decisions. Reliable information is critical to the response: if emergency responders respond to an event without adequate information, they could create risks for themselves or others, or worsen a situation. The balance between information collection and rapid action needs to be carefully struck.

Drones give you an aerial view of a scene - with the right cameras and software, the data drones collect can assist picking up heat signatures, measuring volumes, and calculating distances.

Advantages of using drones for disaster preparedness:

- **Bank of information ready for deployment:** situations like SAR need maps of an area, whilst other responders can use maps of vulnerable areas to predict and plan their actions, such as identify low-points for floods or locations in regions of high seismic activity that are likely to be affected by earthquakes.
- **Risk identification:** analyzing a location means finding details that could later be hazardous. For instance, identifying regions with high deforestation rates, where mudslides or landslides would be more likely, or harbor walls that are dilapidated.
- **Urban tracking:** having up-to-date information about where buildings and people are located helps focus the response in the case of a disaster. Although a city may have records of where residents live, they may not be accurate or reflect the distribution of a population.
- **Topographic surveying:** elevation greatly impacts the vulnerability to a disaster, and the type of disaster more likely to a region. Communities in high, mountainous areas are more likely to face snow-related extreme situations, whereas lower altitude zones will face a greater risk of flooding.

Golden rule

Be aware of past disasters in your aera, even if they are hundreds of years old. Tectonic activity is hard to predict and is generally specific to certain regions of the world, but can be inactive for prolonged periods. Understanding the geographic as well as the human history of your public safety district can help you prepare for the most unexpected scenarios.

There are several specific examples of where drones can help with natural and climate-related disaster preparedness:

- **Flood prevention** - identify flood risks, topographic patterns and predict flood movement and intensity in specific locations.
- **Earthquake preparedness** - identify structures at risk from tectonic activity, such as bridges or dams, as well as densely populated areas with high-rise buildings that may be damaged in a tectonic event.
- **Tsunami prevention/awareness** - find low-lying areas that could be vulnerable to flooding, establish warning systems in those regions.
- **Hurricane/cyclone vulnerability** - similar to tsunami or flood prevention, spot the risk areas and plan management strategies.
- **Avalanche prediction** - analyze mountain structure and shape to predict where snow will gather and plan avalanche management.
- **Wildfire management** - map areas of dry, terrain as well as planned burns, undergrowth clearance, and campfire management.
- **Drought mitigation** - map current water levels and plan for distribution to a region; also to measure plant stress levels to gauge underground water levels.
- **Landslide prevention** - track deforestation in line with precipitation levels to assess risk levels, and evacuate a population as necessary.
- **Volcanic eruptions** - nothing can prevent one, but tracking shifts in a volcano's size, geyser activity, or magma production can help monitor changes in behavior that may hint at a (larger) eruption. Regularly collecting data with drones in the same locations allows scientists to document these shifts and changes.

USE CASE

Mapping the Yangtze River

The Yangtze River in China is the longest in Asia and supports a huge population. The city of Zhenjiang, which hosts a massive inland port, saw 140 million tonnes of cargo in 2013 alone. However, the Yangtze, like most rivers, is liable to flooding. With the spread of urban settlements across China, rivers experience higher loads of water entering the channel faster because of more efficient drainage systems. This increases the risk of flooding, which will happen already as a natural event.

LOCATION
Zhenjiang, Jiangsu province, China

SOFTWARE
Pix4Dmapper

OUTPUT
Orthomosaic

TOTAL IMAGES
21,000

GSD
8 cm (3.15 in)

AREA MAPPED
400 km² (154 mi²)

FLIGHT TIME
40+ hours over 15 days

HARDWARE
MMC Griflion M8 drone
Sony A7R2 camera

GOAL: Produce a high-resolution orthophoto of 100 km (62 mi) of the Yangtze River banks, with 500 m (0.3 mi) depth on either side. The overall map was intended to have a high ground sampling distance.

LOCATION: Dadao river in Jurong City in the west of Xilaiquiao Town in Yangzhong city, including a few islands in the river.

Authorities in Zhenjiang Municipal Flood Control Bureau decided to prepare for flooding by mapping the area around the Yangtze. This huge project mapped over 400 km² (154 mi²). The total flight time was over 40 hours across 15 days, generating 21,000 images. The output was a high-resolution rectified orthomosaic, with a GSD of 8 cm (3.14 inches).

The orthomosaic was combined with existing flood planning maps, water conservation data, and relevant information. These files and data had been stored as separate files. In this project, it was collated to produce a custom base map with Pix4Dmapper.

Key takeaways and tips

- Use zig-zag placement for Ground Control Points, which is best suited for corridor maps and similar projects (for size and scale of the project, 160 GCPs were used to ensure accuracy).
- The high overlap between images aids in maintaining an accurate GSD - this project had 75% frontal overlap and 70% side overlap.
- The combined use of GCPs and RTK/PPK for this project was necessary due to the scale of the area surveyed.

USE CASE

Assessing coastal erosion

Coastlines naturally change as a result of coastal erosion. Cliffs lose shape and structure over time, as unstable parts fall and crash down onto whatever is below - be it the sea or sand. Checking the status of these cliffs and their structure can help inform authorities about the likelihood of a collapse and manage the area accordingly. The danger is not just for people below, but also people or buildings at the top of the cliff that may fall with the land.

LOCATION
Planguenoual, Brittany, France

SOFTWARE
Pix4Dmapper, QGIS, Cloud Compare

IMAGES CAPTURED
604 (site 1), 250 (site 2)

EROSION CAUSES
Powerful storms, worsening with climate change

HARDWARE
senseFly eBee, DJI Phantom 3 Pro

OUTPUTS
Orthomosaic, DSM, point clouds

The survey of the coastline was divided into two phases:

- Measure the cliff baseline
- Survey a tourist walking trail on top of the cliffs

There were several obstacles for this project. The first is that local regulations only allowed the drone a 1km (0.62 miles) range, so the pilot had to land and take off several times. Additionally, they had to hike to the site carrying 20 kilos (44 lbs) of gear. The flight had to be timed to coincide with low tide to capture cliff baseline imagery. Finally, the storms in the area are worst during the autumn and winter months, so the flights needed to be during this period to gather data to show the extent of the erosion, but that meant finding the right weather more difficult.

Key takeaways

- The tourist walking route was found to be dangerously eroded. They did a closer examination which yielded a GSD of 0.7cm (0.2 inches).
- Used open source Cloud Compare to contrast erosion over time. This enabled accurate tracking of the cliff degradation and thus, helped public safety monitor changes.

Response

Sadly, being prepared for a disaster cannot prevent it from happening, especially in the case of natural disasters. Although preparedness helps with saving time and lives, the need for timely and accurate information is key to an effective and successful assessment of the damage, identification of areas requiring urgent action, coordination of the responders, and defining plans on how to distribute resources to meet the needs of the affected area.

In this context, drones are crucial tools in extending the assessment capacity of teams on the ground and enabling them to gather and share essential insights to make decisions faster.

USE CASE

Fast-mapping after Hurricane Dorian

Hurricane Dorian was a Category 5 hurricane that struck the Bahamas in August - September 2019. It happened during a dramatic hurricane year but was the strongest that season. When it struck land, the hurricane was sustaining winds at 297 km/h (185 mph).

LOCATION
Bahamas

SOFTWARE
Pix4Dreact

HARDWARE
FLIR Systems
SkyRanger R70 drone

Hurricanes present several dangerous factors:

- The storm itself, bringing intense precipitation levels.
- Elevated wind speeds can damage structures as well as carry debris which may strike buildings, infrastructure, or people.
- Flooding, caused by the increased precipitation and storm surge.
- Storm surge, where the low pressure of the storm allows the sea level to rise, as a result meaning it can overwhelm current coastal storm defenses. In Hurricane Dorian, the storm surge reached up to 6 meters (20 feet).

Hurricane Dorian left a huge amount of damage. Buildings were flattened and hundreds of people were reported missing. GlobalMedic, a Canadian NGO, worked with the Bahamian government to aid in the disaster response.

GlobalMedic's drone provided situational awareness, helping supply information about where damage was concentrated. Pix4Dreact rendered data in the form of 2D maps that could be inspected as well as measurements.

The team flew as soon as they could, not waiting for ideal weather but instead focused on collecting data as fast as possible. The data collection was crucial to generating maps, which were overlaid on existing surveys and data. The slider tool was then used to compare before and after the hurricane. This was vital in understanding the extent of the damage and deploying resources to where people potentially needed help or rescue.

Key takeaways

- Collecting data quickly was more important than waiting for ideal weather.
- Taking advantage of existing surveys and data saves time.
- 2D maps were valuable as they could be produced more quickly.

PIX4D

USE CASE

Paneveggio forest windslide

In October 2018 in north-eastern Italy, a massive windstorm struck the Provincial Forest of Paneveggio. Winds blew through at 217 kilometers per hour (134 mph), significantly damaging the World Heritage Site. It uprooted up to 8.5 million trees. These trees are especially valuable as the wood is highly resonant and is used to make instruments of high value, including Stradivarius violins.

LOCATION
Paneveggio,
Trentino, Italy

PROJECT AIM
Map and assess forest damage to salvage the wood.

TOTAL AREA MAPPED
9.45 km^2 (3.86 mi^2)

TOTAL IMAGES
3,942

AVERAGE GSD
5.6 cm (2.2 inches)

The forestry authorities called on the Servizio Antincendi e Protezione Civile to help assess the damage. They focused on 11 badly affected locations, a total area of just under 10 km² (3.86 mi²).

Workflow:

1. Check the flight regulations in Italy.
2. Take off from the highest point.
3. Data collection with pre-planned flights, or manually by specialized pilots.
4. Images uploaded to Pix4Dcloud.
5. The 3D model was generated and shared with the forestry authorities.

The 3D model helped assess the damage of the forest and bore good news. 70% of the timber that fell in the storm was recoverable.

USE CASE

Colombia landslide

Colombia is a country with a tropical climate, which means it sees plenty of precipitation all year round. However, unusual patterns in rain can cause problems, as in 2017 when high rainfall triggered a landslide in Mocoa. 4,000 people were displaced and 300 died in the tragic event.

LOCATION
Colombia

PROJECT AIM
Gather data, inform rescue operation

TOTAL AREA MAPPED
200 hectares (495 acres)

OUTPUT
.kml files

Landslides present a huge challenge to emergency response as there is a high time pressure for saving lives and identifying people. The Colombian governmental agency, Unidad Nacional para la Gestión del Riesgo de Desastres (UNGRD) requested international help to cope with the scale of the problem. GlobalMedic sent their RescUAV team to Mocoa to help.

Workflow:

1. Flight planning and automatic execution with Pix4Dcapture.
2. Images imported into Pix4Dmapper.
3. Offline processing with Pix4Dmapper.

Thanks to the generated maps, terrain conditions were assessed on-the-go to deploy emergency responders to sites as fast as possible without endangering them. The maps were also used by local authorities to quantify and manage critical infrastructure damage, identify areas that stood at risk of future floods and landslides, as well as plan actions and infrastructure to allow displaced populations to safely return home.

Key takeaways

- Local input and control of materials is important in planning an effective response.
- Precise flight planning helped save time, with automation proving a big benefit.
- The data is not single-use but was applied for analyzing future risks.

03

Search and Rescue

Search and Rescue (SAR) is an efficiency-intensive field, where saving time can mean saving lives. However, like with many public safety sectors, its operations are very unpredictable. Teams specialized in SAR need to be adaptable, fast, and up-to-date with the latest technology and techniques that can help them in the field.

Before diving-in with drones and SAR, it is first important to recognize factors that affect SAR. These include:

- Weather
- Terrain
- Area being searched
- Number of people missing
- Ground-level obstructions - eg building rubble, rockfalls, avalanches, etc.

Drones and photogrammetry can help mitigate the impacts of some of these factors. This is because live image feeds provide situational awareness. The value of an aerial view is already known in SAR - helicopters are frequently deployed when searching larger areas or uneven terrain. However, using helicopters is expensive and not always widely available. Similarly, a video feed is not always as helpful as it may first appear.

> "Forewarned is forearmed"
>
> **- Gene Robinson,**
> Author of "First to Deploy - Unmanned Aircraft for SAR & Law Enforcement"

Benefits of using drones

- Fast, aerial reconnaissance - assess the terrain, scope of the search area, identify visual clues.
- Widen the search area quickly - gather data faster than a physical team can reach a location.
- High detail and resolution imagery - spotting small details that can be clues to the rescue effort.
- Fast processing or export available - get a map immediately, or share with team members in and out of the field.
- Work offline - have the maps of your response area pre-loaded so being in the field poses no navigational problem.
- Measure distances - inform teams about the width of obstacles like rivers directly from the imagery after processing.
- Specialized cameras - use thermal imaging cameras to see more of the scene and identify lost people in dark or difficult conditions.
- Providing data to aid decision making - understand the terrain and what equipment is required to avoid being caught off-guard or unprepared.

Tips and tricks from SAR drone operation veteran Gene Robinson:

Gene Robinson is an expert on UAV use in SAR. He pioneered the utilization of drone technology to aid search and rescue operations. He has some advice about setting up and using drones in SAR:

1. Plan your flight carefully: this saves battery life and prevents the impact of unexpected factors having too great an effect on the flight.
2. Keep your batteries warm: if operating in the cold, this will sap your battery life. This in turns affects flight duration. Keep the batteries warm, even if that means storing them inside your jacket so body heat warms them.
3. Record your data: regardless of the success of a SAR mission, the data collected should become part of a permanent record available to your organization. If it is needed later, users can access it in a variety of formats. For a new search, this means they can see how the landscape has changed through this archive of information.

Appropriate software

- Pix4D**capture**
  - Free flight planning app
  - Live image feed
- Pix4D**react**
  - Fast mapping
  - 2D orthomosaic view
  - Work offline
  - Geolocated mapping
- Pix4D**mapper**
  - Generate 2D and 3D outputs
  - Use thermal imaging cameras
  - Map and create animated trajectories of a scene

USE CASE

Setting up a drone response kit

Drone Process and the Savoie firefighters set up the OPS BOX to aid in emergency response with drones. The OPS BOX is a mobile command unit that can be set up in the field for gathering live feedback from drones and mapping on-site during an operation. It is designed to serve in fire responses, event management, and area observation.

PURPOSE

Gather information rapidly in the field

DRONE BENEFIT

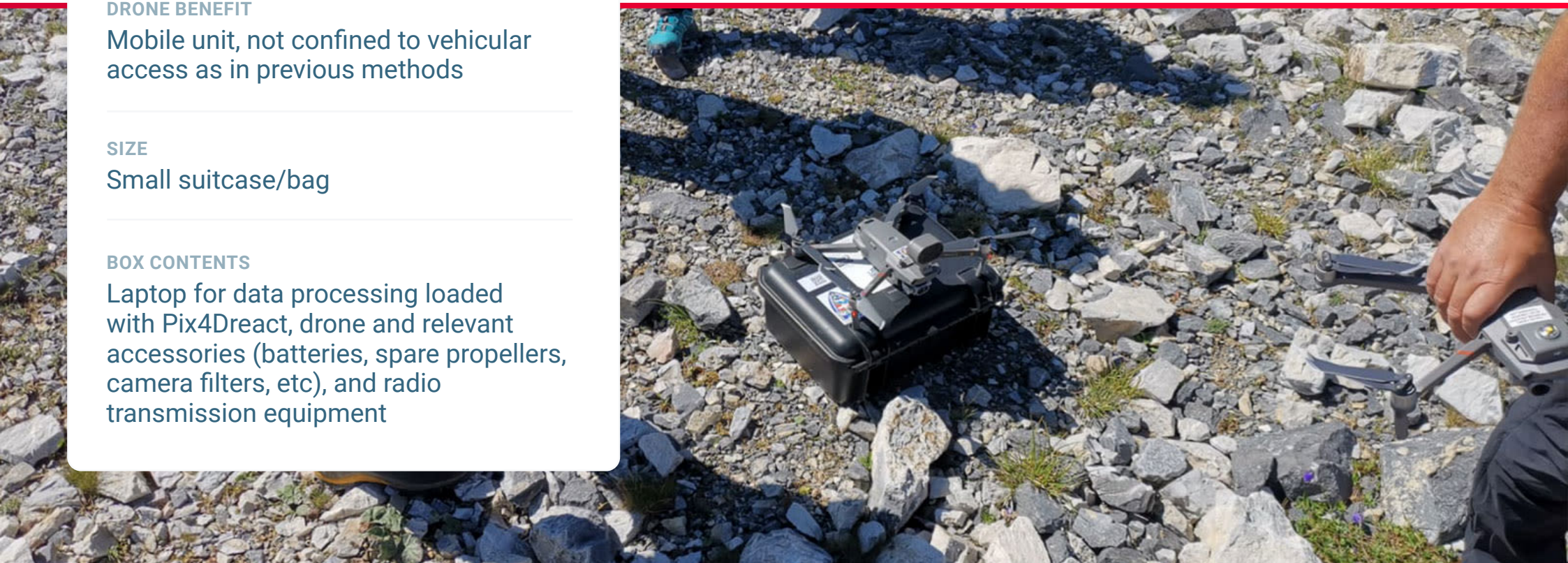
Mobile unit, not confined to vehicular access as in previous methods

SIZE

Small suitcase/bag

BOX CONTENTS

Laptop for data processing loaded with Pix4Dreact, drone and relevant accessories (batteries, spare propellers, camera filters, etc), and radio transmission equipment



Testing

The team tested their box in a variety of extreme scenarios to suit their needs. This included working at 40°C (104°F) as well as -20°C (-4°F).

Deployment

This OPS BOX is in use in the Savoie region of France, in the Alps. The box is deployed in the surrounding area, encountering extreme terrain, weather, and temperatures. For SAR teams, the OPS BOX will help gather information quickly in environments that are not hospitable to isolated human life.

Key takeaways

- The priority for the team was speed and portability.
- SAR is unpredictable, so the hardware and software must be adaptable.
- Defining the box's key uses - fires, events, and observation - helps tailor it to suit SAR.

PIX4D

USE CASE

Search and rescue in bodies of water

The Essex Police in the UK frequently deal with missing persons cases. 80% are found within a day, but the work that goes into the search operations is exhaustive. A particular challenge for finding missing people in Essex is the proximity to water. Whether by accident or on purpose, many cases the Essex Police respond to involve water.

LOCATION
Essex, UK

RISK FACTOR
Long coastline and many water sources and bodies on the mainland

AGENCY
Essex Police

It is impossible to be prepared for everything, but the Essex Police work hard to be as ready as possible. Their Special Operations team trained in Wales, using a large river to stage realistic scenarios.

The workflow the Essex Police have set up is used to save time and understand the water body they are responding to. Mitigating the risks to the emergency response teams helps prevent a disaster escalating to include first responders in distress. This is how they assess a scene:

1. Automated flight over the suspected location of a person (Pix4Dcapture).
2. Load images to the field laptop for processing (Pix4Dmapper).
3. Inspect the images for hazards, such as fast-moving water, potential deep water as well as entry/exit points.
4. Plan a response using this information.

Key takeaways

- Understanding the currents can help the team avoid danger, but also plan how to navigate using the currents to their advantage.
- The SAR team can look at obstacles in the water, such as rocks, which break up the current and can shelter rescuers or a missing person.
- The ability to zoom in allows for aerial reconnaissance - such as the search for entry/exit points of a missing person or hints of their whereabouts.
- Seeing the scene allows for early identification of a missing person and mitigates risk whilst saving time.

04

Crash reconstruction with photogrammetry

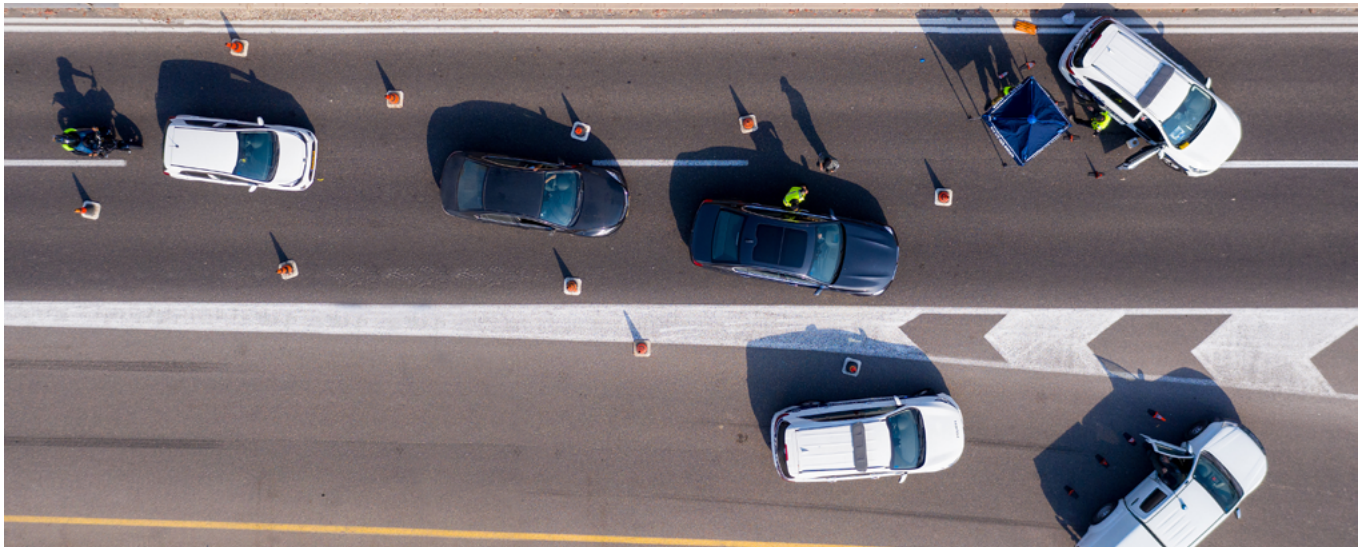
Crashes are dramatic events. Understanding why they happened can determine the cause of the crash, factors that influenced it, and teach authorities how to help protect people in the future. Investigating the scene is important - but taking too long can delay traffic and slow down public safety workers. Drones and photogrammetry can help save time and gather data, as well as give more insight into the scene.

Collect data faster, saving time and effort for public safety officials

Outputs of a collision reconstruction using a drone and photogrammetry software:

- 3D model in color, where views can be changed to understand driver perspective/field of view
- An option to create a 3D animated trajectory to help reconstruct the events
- Measurements of yaw marks (tire skids) and object movement, such as how far items skidded

This data can be used for the investigation as well as evidence in court, which is more persuasive and evocative than simple 2D line drawings or photos.

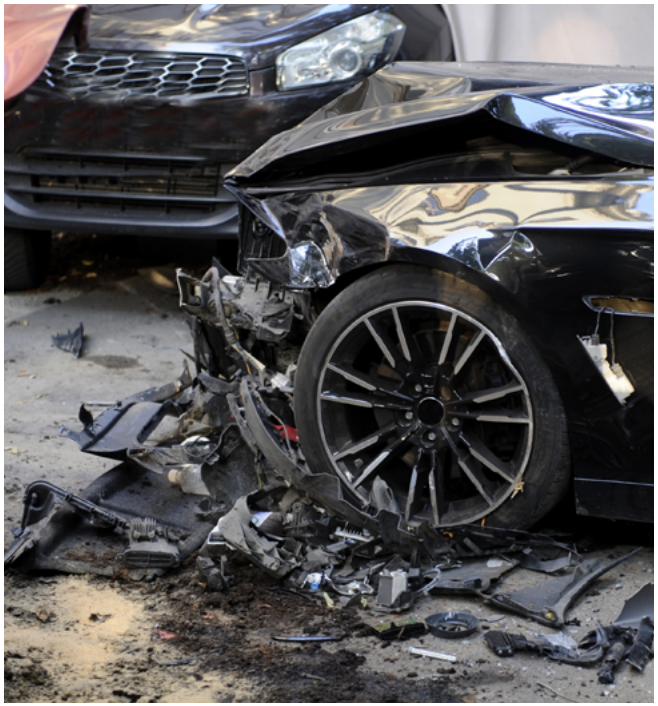


Benefits of collision reconstruction using drones

- Scene inspection time reduced from 2 - 3 hours to as few as 15 - 20 minutes
- Roads re-open sooner
- Improved officer safety
- Reduced rubber-necking as drivers slow down to look at the scene, as well as reduced risk of crashes from distracted drivers
- Reduced fuel consumption and air pollution from shorter traffic delays

Establishing a collision reconstruction workflow

Using drones for collision reconstruction has several advantages, and establishing the right workflow is key to it working effectively.



An example workflow:

1. Survey the scene, ensure it is safe before deploying drones.
2. Identify areas of interest and evidence, and mark with spray paint or cones.
3. Use reference measurements to check against the 3D model generated.
4. Check hardware and flight planning software are ready for deployment - including checking regulations in.
5. Data collection flights are carried out.

Collecting data relies on several important factors. Before collecting information for collision reconstruction, consider taking several factors into account:

- Is the site safe? If emergency responders collect data when unsafe, they risk injury.
- Is the site secure? Data collection with a drone requires as still a scene as possible. If items are moving around the site during data collection, the model may be distorted after stitching.
- Can the accuracy be cross-checked? One option is to take measurements on-site to compare to the same measurements in the model to check its accuracy.
- Use the right hardware – decide between a rotary drone (more maneuverable) and a fixed-wing drone (longer flights, handsfree).

Is night photogrammetry possible?

Yes. Crashes are likely at night - drivers may be tired, have poorer visibility, or be distracted. Collecting data in the dark is challenging. We recommend focusing on improving your lighting:

Street lighting can be sufficient when combined with high contrast paint, chalk, or evidence markers.

Lighting towers and squad car lights can illuminate evidence areas when positioned strategically.

Built-drone or camera light sources usually provide sufficient illumination at typical flight heights of 100 feet (30m) or under. The UAV must be kept still when the camera shutter is activated to avoid motion blur caused by the required longer exposure times.

Golden tip for data collection in the dark: fly twice

Results generated with night imagery can be compared with results from images captured in the day. The images should not be processed in the same project to avoid confusion due to light distortion. The benefit of comparing results means you can spot missing evidence that is not easily identifiable in the dark.

Software solutions that can help with crash reconstruction:

- Pix4D**mapper**
- Pix4D**react**
- Pix4D**capture**

USE CASE

How to get the best out of a crash investigation

Aerial Metrics, an Illinois-based company of specialists using sUAS to improve crash investigations, use DSLR photography to build models in Pix4Dmapper. We've taken their workflow as an example workflow for crash reconstruction:

1. Once the scene is safe, evidence on the roadway and surrounding areas is identified and marked with spray paint, evidence tents, or versa-cones.

2. Take two or more scale reference measurements taken between easily identifiable points at least 15m (50 feet) apart. These are used later to verify the accuracy of the photogrammetric model.

3. Before the team starts with mapping flights, they do a quick preflight check to ensure hardware/software function and regulatory compliance.

4. Three flights are conducted over the scene or subsets at progressively lower heights. The pilots are trained to determine the appropriate heights and photographic overlap distances for each layer. The first and second layers cover the same area. The third (lowest) covers only the area of key evidence and may also include obliques of vehicles. The easiest way to think about it is that the middle run is primary, the higher run is insurance in case of inadequate overlap, and the lowest run improves resolution/GSD for the most critical evidence.

Each flight works as follows:

- Flight 1 - Drone passes down the middle of the scene to capture site width with 75% frontal overlap.
- Flight 2 - Drone is flown lower, at 2/3rds of the first flight height. Includes a pass on the left and right sides of the scene.
- Flight 3 - Drone is flown yet 50% lower again to identify specific evidence.
- 5. Once the flights are concluded, the evidence and vehicles can be removed, and the roadway opened for traffic.

Key outputs for crash investigation

Richer data capture

- Full three-dimensional model reconstruction with millions of data points.
- Equal or better accuracy: sub-centimeter accuracy is achievable.
- Retroactive measurement ability: With total station capture, distances to be measured must be selected at the scene. With UAV capture, any measurements can be made once the model has been created.

Compelling evidence in court 3D color models are very compelling in court.

- Viewpoints can be changed to any location within the scene, showing what a driver or witness would have been able to see.
- 3D models are much more persuasive than 2D line drawings or primitive animations.

PIX4D

Drones have a wide range of uses in public safety, and this eBook serves as a guide for just how it can work, with real-life examples.

This eBook relied on the expertise and knowledge of experts around the world and we are grateful to them for sharing what they have done and learned.

Want to learn more about drone mapping in public safety and emergency response?
Contact us at **pix4d.com/contact**