AERIAL PERSPECTIVE

Ontario Provincial Police quickly document a semi-truck crash in a remote area of Canada using a small electric powered helicopter.

Photo credit: Marc Sharpe
Acting/Sgt-Unit Commander
Ontario Provincial Police
Kenora Forensic Identification Unit
Explosive Disposal Unit

Here we explore this aerial technology

and understand what's involved to use these new tools

By Mark Bateson

As a technology consultant to the industry over the last 39 years I've had the opportunity to develop and work with new and emerging technologies worldwide.

My in-depth involvement with small unmanned aircraft started in 2005 designing, building, and flying both fixed wing and helicopter systems.

In this article I'll be discussing the use of small Unmanned Aerial Systems (sUAS) in public safety; most specifically for the purpose of collecting forensic aerial data, pointing out the benefits, things to watch out for, and how they are being used.

Immediate benefit:
As the old saying goes, "a picture is worth a thousand words" and getting this aerial perspective often provides new insight into "what happened", aids in measuring a scatter field or provides an excellent visual during prosecution to paint the big picture for the jury.

Is an aerial shot something new to the forensics world, no, of course not, but what is new is the ability to quickly deploy your own aircraft and get shots you need the first time. I've seen it happen where agencies that have an aviation unit describe what shots they need only to get "not exactly" what they wanted or in other cases, having to call in the fire department or call in a basket from city works to get an elevated aerial shot.

With many of the new aerial systems currently available you can easily fly the aircraft to the desired position, altitude, park it there in a GPS position hold and then focus your energy on remotely operating the camera angle, zoom, and shutter. The video is broadcast live to your location so you can easily frame and get the shots you need the first time.

They're just flying things:
Just a few years ago selecting a system and getting it in the air was a pretty easy thing to do. There were just a handful of excellent products on the market but as I write, the number of companies offering solutions worldwide has expanded dramatically varying in price, capability, reliability, quality and so, buyer beware.

I say "they're just flying things" because in the end you're not out flying for fun; you're out to collect data and get the job completed. A good quality aircraft is very important but even more so, is the camera payload system that it's carrying.

For example, I have seen some excellent aircraft but the camera system was really very poor, and just the opposite problem, where the camera offered was amazing but the aircraft could marginally keep it in the air.

Damaged bridge inspection: "There was no safe way to inspect the damage so we flew our new Draganflyer X6 out over the river to get the photos needed. It was nerve racking. We had the PAFD boat crew in the river below in case there were problems but everything worked out well"

SGT. Shawn Stubbs
Forensic Identification Services
Price Albert Police Service, Canada

What to look for:
Talk with other agencies that are currently flying aircraft to learn more about their experiences but in general what you find on the market are imported products from China, Europe, or aircraft being assembled from various component suppliers then marketed as a complete system, or you'll find a few original manufacturers.

Personally I prefer original manufacturers because they're typically designing their own aircraft, autopilot, writing their own software, and designing the complete system. With the in-house knowledge, experience, and control over the product you get the best possible system. Does it mean the other systems are bad, no, if everything works perfectly it doesn't. The time I've seen people run into problems is when something on the aircraft fails. Getting it fixed can sometimes be an involved process where as, with the original manufacturer, there is no finger pointing.

In regards to features I suggest staying away from completely automatic systems because if anything ever goes wrong, you want the ability to manually take control of the aircraft and get it to the ground safely.

Features I find very useful are autopilot assisted altitude hold and GPS position hold. When flying in altitude hold mode the autopilot manages throttle/altitude for you so in operation, you basically fly to the altitude desired and from there the autopilot maintains altitude as you fly the aircraft. Once in position I will always take advantage of the GPS position hold feature. I call it "parking the aircraft" because once switched into this mode, the helicopter will hover in position and maintain altitude by itself while you remotely operate the camera to get the photos needed.

Corporal Doug Green, RCMP
The X4-ES aircraft is part of his kit and flown on a daily basis. May of 2013 Cpl. Green was the first public safety officer in the world to save a life using this aircraft & FLIR thermal camera.

Payload systems:
People that know me always hear me saying, "it's all about the payload". And I stated earlier that yes, you need a good aircraft, but it's the payload system that's taking the photos and collecting the data needed to get the job done.

In very general terms you want the best quality and the most control over your photos as possible. And to be more specific, I like having control over shutter speed, a remote zoom, and a large sensor with as many pixels as possible.

Camera technology is making leaps forward with new product, where just about every quarter a new camera comes on the market.

As I write, some of the more popular cameras being flown are the Sony NEX series, the Sony RX100 and most recently a new concept in photography, the Sony QX100 lens camera.

Camera mounting, vibration isolation, and stabilization are also very critical features of the payload system. Just like any helicopter, these multi-rotor helicopters generate some vibration and so during testing, I established a simple scoring model where I'll get out and park the aircraft in a 30 or 40 meter hover and as I rotate 360 degrees at different

camera angles rattle off 50 to 100 photos at different zoom settings; then at the comfort of my desk, “score” the results. What I’m scoring is the percentage of clean, crisp, level shots versus photos with motion blur.

On a calm day more often then not you’ll get good numbers with most systems but the real test is a windy day and why?

With multi-rotor helicopters they must “tilt” to fly. When hovering in a no wind condition the helicopter is level but when you command it to fly forward, it tilts forward and begins to move.

Now imagine that you’re hovering in a GPS position hold and the aircraft is hit by a big gust of wind. The autopilot senses being pushed off the GPS point so it must “tilt” the aircraft as illustrated below, flying back into the wind to maintain the GPS position. So what this all means is that in windy conditions you’ll see the aircraft tilting this way and that, maintaining it’s position for you.

Photo credit: Mark Bateson

If the camera were hard mounted on the aircraft the photos would be tilted when hovering in a cross wind. To resolve this issue most aircraft today are using gyro stabilized payload systems like you see above to keep the camera independently level, even when the helicopter is in flight or fighting the wind.

Video downlinking systems:
To frame the shot and get the photos or video that you need, it’s best to have a live video feed broadcast from the aircraft directly to your handheld controller, attached video monitor, or base station.

With some systems the video display is built into the handheld controller or clipped on as an accessory. Some systems send video to a separate base-station computer or display. Video is broadcast as either an analog or digital signal. An analog signal is susceptible to static interference and a softer look where a digital downlink has a more crisp, sharp image. When a digital link experiences interference you will see pixelation in the image or a “freeze” frame in poor signal conditions.

Some digital systems are also broadcasting live video directly to handheld devices like cell phones, tablets and system networks.

With most systems the video downlink feed is used only to frame your shot with the high resolution image stored on the camera memory card or perform surveillance work.

Air space regulations:
The regulatory issues surrounding the aircraft could fill a book so in brief, it’s best to check with the agency within your country that controls the National Air Space to understand their rules, requirements, and certification process.

What you’ll find is that some countries are very progressive taking a common sense approach to the issue with Australia, Europe, Japan, and Canada leading the way while countries like the United States are lagging far behind.

The good news for the United States is that there is a process for public safety agencies and universities to get a waiver called a COA, to legally operate the aircraft during day light hours, within line-of-sight, in the National Air Space.

Photo credit: Cpl. Doug Green RCMP

Real work being done:
Yes, there is real work being done with these systems worldwide ranging from tactical operations, search and rescue, HAZMAT operations, Bomb Squad, detailed aerial mapping, detailed aerial mosaics, to crime scene and traffic collision documentation. The images and video tell a story either in real-time or later during the investigation and ultimate prosecution. For example in

Photo credit: Cpl. Doug Green RCMP

these two photos you see damage to the auto but when viewed from a higher altitude, look at the length of the collision scene illustrated above. You can’t appreciate it in this publication but the detail and resolution of these photographs is amazing.

Other tools:
Quite often the live video feed either provides live tactical or search/rescue information or allows the operator to frame the shots needed.

After flying the mission, the camera memory card is removed and the post processing of the data begins.

The post processing can be as simple as going through and looking at each image for the information needed or in the case of building a large mosaic image, electronically stitching the images together. Some of the software on the market today provides incredible precision to create highly detailed and accurate mapping information to less than centimeter accuracy.

Take this a step further and it will be discussed in more detail; a sequence of images can be used to create a photo realistic 3D visual model of the crime or collision scene. The results can be stunning, allowing detectives and or the prosecution to easily view the scene from any angle, measure points and see things that might have been overlooked while walking the incident.

I have not seen it done yet but conceivably you can take a 3D crime scene model generated by the aircraft and send it to a 3D printer, creating a physical model that everyone can touch and see.

Aerial 3D modeling:
Photographically documenting a crime or accident scene isn't anything new. Several agencies are using 360 indexed camera heads and their favorite software applications to recreate the virtual crime scene within a room or building.

What is new, is the ability to create even larger computer models with the use of these small unmanned aircraft. For example, a serious traffic collision as illustrated above that is spread out over a large area. A crime scene that starts outside a home and moves indoors, or an outdoor crime scene covering a large area.

One agency very much involved with this technology is the Mesa County, Sheriffs' office in Colorado. The agency is respected as a leader in the use of small unmanned aerial systems in the United States flying both small helicopter systems for crime scene work, as well as small unmanned fixed wing aircraft for search and rescue missions.

When the team arrives at the crime scene one of the first steps is to closely work with the lead investigator to determine the "boundaries of the scene" because as Benjamin Miller, director of the unmanned systems program for the Mesa County Sheriff put it, "we just have one shot at capturing all the images before things start to change, so we want to get it right." He continues to say, "The first step in documenting or recreating a crime scene is measurement. We must be able to accurately place all items in a crime scene and understand their relationship with one another". A benefit of using this technology whether it's a serious traffic collision or investigation is the ability to process a scene much faster than before. As Mr. Miller stated, "this technology speeds the process and reduces our time on scene, the time a road is closed, the time a business is closed, or not allowing a family back into their home. This new technology helps us considerably and the people we serve".

3D Point cloud data and resulting 3D model from the White Hall fire in Grand Junction Colorado Sept, 2011.

Image data courtesy of: Benjamin Miller Unmanned Aircraft Program Director Mesa County Sheriff, Colorado

Benjamin Miller, Mesa County Sheriff
On the left screen you see many of the aerial images used to construct the computer 3D model and on the right, an interactive computer model of the scene.

And as you look at different systems on the market you'll learn that aircraft system capabilities vary. With some systems you need to manually fly a grid pattern over the crime scene or with others, you simply define the extents of the grid on the aircraft handheld controller or base station controller, and let the system automatically calculate the pattern, frequency of photos and fly the aircraft for you. As I mentioned earlier, I like the ability to manually take over control of the aircraft if needed, and even with an automated grid search, with most systems regaining manual control of the aircraft is as simple as the flip of a switch.

The real secret to getting good aerial mosaic images or 3D image reconstruction is taking sharp, crisp images and maintaining the same altitude with good image overlap.

Most of the software programs like Pix4D, Photo Scan Pro and others, are looking for 60-80% overlap to accurately align and merge photos into one seamless, scale, very large, unified image or computer model.

Most people are accustomed to seeing large flat ortho rectified images in mapping programs like GoogleEarth but the power of this software and capability is so much more.

The image data can be used to build these amazing interactive 3D models as you see above to perform complex measurements within the scene, between objects, vehicles, skid marks, or even calculate complex areas to determine volume.

All these functions are performed during post processing of the data and at least for the Mesa County Sheriff, their DA's office and others are beginning to expect this level of quality aerial imagery and forensic data.

Photos from a live, armed stand-off scene. Aerial photos from a Draganfly X4-ES helicopter were provided to tactical specialists arriving on-scene. Images were used to plan the approach and confirm no entry/egress from doors in fresh snow overnight. The aerial over flight also pointed out a large dog under deck.

Photo credit: Richard Cunningham
Identification Constable
Ontario Provincial Police
Thunder Bay Forensic Services Unit

Conclusion:
In conclusion I've covered quite a bit of information in regards to the aircraft, the importance of good payload systems, and hopefully provided some tips and insight into the amazing benefit these aerial tools have to offer.

The aircraft are easy to fly and factory flight training is typically a two or three day affair. Keep in mind that learning to fly is just the beginning because like anything, to get really good at it you need to be out there flying as often as possible. Flight training gives you the knowledge and skills to fly but practice makes you good. Over the long haul they are flying computers so keep in mind that over time, there will be firmware and software updates to improve their capabilities and keep them flying.

Luckily for public safety agencies and universities, aircraft regulatory issues are nothing more than a paperwork hurdle. Even here in the United States if you follow the process, the FAA will work with public safety to get you flying under a Certificate of Authorization (COA) and as I mentioned earlier each country is different, but in most cases a process is in place to get your aircraft operating legally in the air.

The benefits of using these aircraft are too great in number to mention but specifically to public safety, to have a tool like this at your disposal is invaluable. The aircraft can typically be assembled and deployed in less than 5 minutes time and depending on the aircraft, weather, and payload, stay airborne anywhere from 10 to 40 minutes.

For aerial photography and mapping it's amazing how much work can get done in just 10 to 20 minutes documenting an incident. For tactical operations even a 20 minute flight time is good for something like an attempt pick-up or SWAT entry as illustrated above.

For longer tactical operations or search/rescue work I suggest using a small electric powered fixed wing aircraft. Some of the planes are carrying very sophisticated payloads and staying airborne for 60-90 minutes allowing you to stay in orbit on-station, or covering a lot of ground flying pre-programmed grid search patterns.

In summary these tools are here to stay, they are incredibly affective, and lucky for us, very easy to use.