CHAPTER 6: UAVS AND HUMANITARIAN RESPONSE

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The first high-resolution aerial image of a major disaster was a black and white photograph of San Francisco in ruins after the devastating earthquake of 1906. A large 49-pound camera attached to a set of kites captured the damaged city from 112,000 feet in the air. The photographer, George Lawrence, sold prints of his aerial image of the city to intrigued individuals for $125 apiece, netting him close to $400,000 in sales (in 2015 dollars).[1] Other early users of aerial imagery in disaster situations included the military. In 1923, the U.S. Air Force took aerial photographs of the Honda Point disaster in California after seven large ships ran aground during a foggy night.[2] Over the course of World War I and World War II, militaries around the world made strides in the use of manned aircraft to capture aerial imagery for reconnaissance purposes. At times, this included assessing disaster damage following air raids such as those carried out on Berlin in 1945. Additional examples of aerial imagery use over the past century relate to major mining and industrial disasters, including Chernobyl in 1986. Aerial imagery was also used in the wake of Hurricane Mitch in 1998. More recently, unmanned aerial vehicles (UAVs) were used to capture aerial imagery following the 2010 Haiti earthquake,[3] while manned aircraft captured imagery after Hurricane Sandy in 2012 for damage assessment.

Aerial imagery of disaster-affected areas is still in great demand today. Indeed, national and international humanitarian organizations are increasingly turning to aerial imagery captured by UAVs to assess infrastructure damage and resulting needs after major disasters. UAVs provide a number of advantages over manned aircraft and satellites. Manned aircraft cannot be programmed to follow designated routes that require very precise flight paths and tight turns, for example. In addition, manned aircraft are typically more expensive to operate and maintain than small UAVs and tend to require a lot more infrastructure, such as runways. Compared to satellite imagery, aerial imagery from UAVs is available at considerably higher spatial resolutions. The most sophisticated commercial satellite available today offers imagery at a resolution of 31 centimeters,[4] while aerial imagery can generate sub 1-centimeter resolution. UAVs can also capture high-resolution oblique imagery by positioning cameras at an angle—say, 45 degrees—rather than straight down, which is known as nadir imagery. This enables the creation of very high-resolution 3D models.[5] UAVs, unlike satellites, can operate below cloud cover. Lastly, while just a handful of multibillion-dollar companies can own and operate satellites, international humanitarian groups, national disaster management organizations, and local communities can own and operate UAVs themselves.

Over the past several years, UAVs have been used in response to, among other natural disasters: the Nepal earthquakes (2015), Cyclone Pam in Vanuatu (2015), Typhoon Ruby in the

This photograph of San Francisco was taken by George Lawrence 6 weeks after the 1906 earthquake. (Image from Wikimedia Commons.)

Philippines (2014), the China earthquake (2014), Cyclone Ita in the Solomon Islands (2014), flooding in Bosnia and Herzegovina (2014), Typhoon Haiyan in the Philippines (2013), and Hurricane Sandy in New York (2012).[6] This chapter provides an introduction to the use of UAVs for humanitarian response by outlining the opportunities and challenges presented by this new technology.

HUMANITARIAN UAVS

UAVs have relevance across the entire disaster cycle—from risk reduction to preparedness, response, search and rescue, recovery, and reconstruction. This chapter focuses specifically on post-disaster applications of UAVs.* As evidenced by recent humanitarian efforts in Nepal and Vanuatu, UAVs are increasingly used to support traditional damage and needs assessments. Indeed, humanitarian groups are turning to aerial surveys to complement or accelerate their traditional field-based damage and needs assessment surveys. These damage assessments typically include buildings (such as dwellings, schools, and hospitals) and transportation infrastructure (roads, bridges, etc.). Field-based surveys are time-consuming, often taking weeks to complete. Questionnaires, like the United Nations' Multi-cluster Initial Rapid Assessment (MIRA) and the World Bank's Post Disaster Needs Assessment (PDNA), include dozens of questions to guide the on-the-ground assessment of disaster damage and ensuing needs.[7] In addition to being time-consuming, field surveys suffer from data quality issues; individuals filling out these questionnaires may interpret the questions differently or overlook important questions.[8] Aerial surveys can accelerate the damage assessment process by prioritizing those areas that require field surveys, while also serving as an important quality control mechanism to triangulate and complement field-based surveys.

Oblique imagery is considered more useful for disaster damage assessment purposes than nadir imagery, since the angle provides the necessary perspective to assess whether the walls of buildings are damaged. That said, unlike nadir imagery, oblique images cannot easily be "orthorectified"[9]—that is, be corrected so points on the picture correctly correspond to points in the real world that can be tagged by GPS. This currently limits the analysis of oblique imagery to purely manual methods when integrating the results with other GIS (geographic information system) data.

* Humanitarian organizations do not typically take on the responsibility of search and rescue (SAR) efforts, which are primarily carried out by the military or other dedicated SAR teams. See box on page 59 on search and rescue.

Medair and DroneAdventures

This mosaic of photographs taken from a drone shows an area in the Philippines damaged during Typhoon Haiyan/Yolanda in 2013, a few months after the storm. It was one of the strongest storms ever recorded; it killed over 6,000 people in the Philippines alone.

Using oblique images to interpret disaster damage in nadir images is thus a useful method. Another approach is to create high-resolution 3D models from nadir and oblique imagery. These models—also referred to as "point clouds"—can be produced using standard software packages. Point clouds provide analysts with a full surround-view, fly-through model of an affected area. 3D models thus have an obvious advantage over standard nadir and oblique images, since the latter are limited by a fixed perspective.

Aerial videos can also provide important insights on disaster damage, though they are often time-consuming to analyze. Moreover, as in oblique images, features in aerial videos cannot be easily georeferenced. Nevertheless, aerial videos have been used to provide additional situational awareness for particularly dense urban areas affected by disasters, for instance after Cyclone Pam in Vanuatu in March, 2015.

Other common applications of UAVs include road-clearance operations and logistics support. Aerial imagery can help humanitarians identify which roads are blocked by debris and which may still be passable. In addition, UAVs can be used to identify locations for setting up a humanitarian base of operations and areas in which displaced populations can be relocated. Other uses include identifying displaced populations, estimating population numbers, and locating remains of the deceased. Non-operational applications for aerial imagery include advocacy, awareness-raising, and public communications.

UAVs can also be used to carry small payloads and to provide communication services (3G/4G, WiFi), but these uses go beyond the scope of this chapter. Humanitarian organizations such as the U.N. World Health Organization and Médecins Sans Frontières (MSF) are testing the use of UAVs to transport lightweight medical payloads like vaccines and medication across some 30 to 50 kilometers.[10] This is a particularly promising use from a technology and logistics perspective, which is why Amazon, Google, DHL, and others are actively pursuing drone delivery. The Emergency Telecommunications Cluster (ETC), an international network of organizations, is also exploring the use of UAVs for communication services. While the ETC's experts suggest this use of UAVs won't mature as quickly as other applications, companies such as Google and Facebook are investing millions of dollars to provide aerial connectivity solutions.

THE SEARCHERS

Search and rescue specialists are beginning to experiment with using drones as a complement to older techniques: helicopters, dog teams, and on-foot sweeps. Drones have already been used to make some notable finds, but the technology has yet to be adopted widely, due to both technological and regulatory barriers.

Perhaps the first search-and-rescue find made with a UAV took place in May 2013, when Canadian Mounties in Saskatchewan province used a Draganflyer X4-ES drone to find a man whose car had flipped over in the snow.[*] A ground search and a helicopter sweep both failed to find the young car-crash victim, but the drone, equipped with an infrared camera, managed to detect his heat signature. In a separate incident, in July 2014, David Lesh used his drone to find 82-year-old Guillermo DeVenecia in a Wisconsin bean field. The old man had been missing for three days.[†]

Texas EquuSearch began as a mounted search and rescue team, but founder Tim Miller says that his group has used its drones to recover the remains of 11 people since 2005.[‡] In April 2015, a Maine search-and-rescue organization became the first civilian entity to receive official Federal Aviation Administration permission to use drones in its operations.[§] In December 2013, Jim Bowers founded a volunteer group in California that uses drones in search and rescue. Bowers' group, called SWARM, now has members in 31 countries.[¶]

Ben McCandless of the Appalachian Search and Rescue Conference, a volunteer group, says UAV's short battery life limits their capability, along with constraints in visual and infrared sensor quality.[**] Few protocols exist to ensure the safety of human searchers while UAVs are flying overhead, he notes. McCandless speculates that the development of such protocols, and effective techniques more generally, is hampered because some search and rescue professionals who use drones are skittish of running afoul of regulators, and so do not discuss their efforts. It seems clear that as technology improves and regulations liberalize, drones will become only more useful in searches for missing people, in the wild, and after accidents and natural disasters.

-Faine Greenwood

* "Single Vehicle Rollover – Saskatoon RCMP Search for Injured Driver with Unmanned Aerial Vehicle," Royal Canadian Mounted Police, May 9, 2013, http://www.rcmp-grc.gc.ca/sk/news-nouvelle/video-gallery/video-pages/search-rescue-eng.htm.

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¶ Ben McCandless, Bill Rose, Paula Repka, and Michael Hansen, "Unmanned Vehicle Use in Search and Rescue Operations" (unpublished manuscript, October 11, 2014) PDF file.

** Ibid.; Ben McCandless, interview with author, June 29, 2015.

VANUATU AND CYCLONE PAM

In March 2015, a Category 5 cyclone devastated the islands of Vanuatu. The World Bank activated the Humanitarian UAV Network (UAViators.org) to carry out aerial surveys that would complement the bank's field-based disaster damage assessments of buildings.[11] UAViators identified two professional UAV teams in the region, which were subsequently contracted by the bank for the mission. The UAV teams used multi-rotor UAVs (hexacopters and quadcopters) to survey about 10 percent of the affected areas. Both nadir and oblique images were collected at approximately 5-centimeter resolution. Aerial videos were also captured. The nadir and oblique images were subsequently analyzed using a three-tiered scale provided by the bank: completely destroyed, partially damaged (i.e., repairable), and largely intact. Orthorectified mosaics drawn from the nadir images were first analyzed by Humanitarian OpenStreetMap, a group of crowd-sourced volunteers. MicroMappers, another such group, analyzed some 2,000 oblique images. The resulting analysis was used to complement the field-based surveys. 3D models were not used to carry out more in-depth assessments because the World Bank was not initially aware that 3D models were an option.

The success of this UAV mission was largely the result of collaboration among the World Bank, UAV teams, the government of Vanuatu, air traffic control, and the Australian Defense Force (ADF). The government gave the teams permission to fly using Extended Line of Site, which meant the UAVs could cover more ground. In addition, thanks to the strong collaboration between air traffic control and the ADF, the UAV teams were able to operate safely near the international airport despite the presence of commercial and military aircraft in the vicinity.

The most pressing challenges related to weather, logistics, connectivity, and data formatting. On logistics, moving across the main island and accessing outlying islands proved particularly difficult due to the terrain and the lack of reliable transportation (both marine and aerial) to the outer islands. Limited Internet connectivity also added significant delays—often days—since it took a lot of time to upload the large files of aerial imagery to the Web. Finally, the lack of consistent labeling of the aerial data caused further delays, since no one in Vanuatu was tasked with this job. The resulting data was thus difficult to access and make sense of.

NEPAL EARTHQUAKES

An unprecedented number of UAVs were used in response to the devastating Nepal earthquakes in April and May 2015. The U.N. Office for the Coordination of Humanitarian Affairs (OCHA) publicly encouraged UAV teams to check in with the Humanitarian UAV Network (UAViators) for the purposes of coordination and safety. A total of 15 UAV teams liaised with UAViators, as did a number of humanitarian organizations including OCHA, UNICEF, UNESCO, the World Bank, and the International Medical Corps.[12] The latter requested aerial imagery of specific sites for a variety of reasons, ranging from disaster damage assessment to population displacement. The majority of UAV assets used in Nepal were multi-rotors.

The lack of UAV regulations in Nepal posed a number of challenges. Some UAV teams chose to assume that the lack of regulations meant they could operate as they wished without seeking permission. This backfired. Several teams were arrested by the police and over a dozen UAVs were confiscated.* Within a week of the first earthquake, the government of Nepal significantly limited the use of UAVs to those efforts that clearly had an official humanitarian purpose. In other words, "drone journalists" were in effect banned from operating. The process to request official permission was unclear, however. UAV teams had to request two separate permissions, one from the Civil Aviation Authority for operating UAVs and one from the Ministry of Information and Communications to capture pictures and videos from UAVs.

As a result of these constraints and uncertainties, the most active UAV teams partnered directly with the Nepalese military, police, and other authorities. These UAV teams shared their imagery exclusively with the government entities and not with international humanitarian organizations. Besides the lack of regulations, other major challenges included limited Internet connectivity, difficulty in accessing rural areas, and the lack of long-range, fixed-wing UAVs.

BEST PRACTICES

Using UAVs for disaster response is very different from using them for journalism, crop management, or real estate marketing. While this should be obvious, the main reason that mistakes are made with UAVs in humanitarian settings is because those drone operators have little or no

* In part to prevent such incidents, the UAViators code of conduct (online at http://uaviators.org/docs) recommends always seeking permission of local authorities.

Building fixed-wing drones with a team in the Philippines.

SKYEYE

Oblique imagery taken from a drone used in damage assessment

background in disaster response. Meanwhile, seasoned humanitarians using UAVs for the first time may assume that they know what they're doing because they have years of experience in disaster management. This shortsighted logic can have dramatic ramifications for those legitimate and experienced UAV teams who are working directly with established humanitarian organizations to support their relief efforts. In the case of the 2015 Nepal earthquakes, the above logic, coupled with the presence of "drone journalists," was in part responsible for the government's decision to heavily limit the use of UAVs post-disaster.

What follows is a summary of some of the most important guidelines drawn from the Humanitarian UAV Network's Code of Conduct and Best Practices documents.[13] As such, it is not comprehensive and should be viewed as a minimum set of guidelines to ensure the safe, coordinated, and effective use of UAVs in disaster response.

UAVs are not always the most appropriate technology to use for the humanitarian tasks at hand. If they are, then UAV operators should be sure to select the appropriate UAV model for the mission and that they identify an appropriate spatial resolution for the imagery collected. They must keep in mind that there is a trade-off between resolution and how much surface area a UAV can cover. Second, UAV operations should stay legal at all times. UAV operators should research the regulations in the country of interest. If no regulations exist for the country in question, this does not mean operators have the right to operate UAV(s) as they like. Even when clear regulations do exist, it is the operator's responsibility to check in with the country's civil aviation authority or aviation ministry to ensure they have all the required permits. If operators are not able to contact these institutions, they should be sure to approach local government authorities such as a mayor's office and local police to request permission.

Once a UAV team has been granted official permission to operate, this does not mean they can ignore the local communities they fly over. It is particularly important to engage local communities and involve them in UAV missions. UAV teams must take the necessary time to explain what they want to do and why. They must clearly demonstrate the added value that their UAV missions are expected to yield and let communities know who will have access to the resulting imagery, how, and for what purpose.

If operating in a complex airspace—one with passenger aircraft, commercial airplanes, humanitarian cargo aircraft, or search and rescue helicopters—then operators will need to liaise directly with the military and the closest air traffic control tower.

UAViators actively promotes the sharing of aerial imagery during disasters in order to inform relief efforts. The network suggests using the Creative Commons CC BY data-sharing license. This license requires that imagery be attributed to the person or organization that gathered it and enables humanitarian groups to integrate data derived from that imagery into other data sets for disaster assessment and decision-making purposes.

Note that data sharing typically entails pushing imagery to the Web. This can be particularly challenging in disaster zones, since cellphone towers and other communications infrastructure may have been damaged. Aerial imagery can often run into gigabytes worth of data. Uploading this data when there is limited or spotty Internet connectivity can significantly slow down if not entirely halt humanitarian UAV missions. Humanitarian drone operators should be sure to plan for the additional technology they'll need to bring if you expect to face connectivity issues. They should determine earlier rather than later which format and labeling standard will be used to share the imagery with partners.

Humanitarian UAV missions do not end when the UAVs land. The main purpose of using UAVs in disaster response is to collect data to accelerate and improve timely decision-making. This requires that the collected data be processed and analyzed, and that the results are shared with appropriate end users. Aid and development organizations typically use their own damage assessment methods to classify structures as destroyed versus damaged versus largely intact. GIS and imagery analysts within these organizations tend to carry out this classification process manually. Platforms such as Humanitarian OpenStreetMap and MicroMappers have also experimented with crowd-sourcing to analyze disaster damage in nadir and oblique aerial imagery.[14]

In alleviating suffering after a natural disaster, time is of the essence. The speed with which UAVs can gather data about affected areas makes them an important tool in disaster response. As the technology matures, the uses of unmanned aircraft in the aftermath of natural disasters will only increase. §

ENDNOTES

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