USAID GLOBAL HEALTH SUPPLY CHAIN PROGRAM

Procurement and Supply Management

Unmanned Aerial Vehicles Landscape Analysis:

APPLICATIONS IN THE DEVELOPMENT CONTEXT

An in-depth landscape analysis of the various actors, objectives, and lessons learned from existing UAV programs operating within the humanitarian supply chain

USAID FROM THE AMERICAN PEOPLE

PEPFAR U.S. President's Emergency Plan for AIDS Relief

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Cover photo: Quad copter in flight. (Credit: Don Mccullough / Flickr Creative Commons)

INTRODUCTION

The USAID Global Health Supply Chain Program – Procurement and Supply Management (GHSC-PSM) project functions to ensure uninterrupted supplies of health commodities in support of U.S. government (USG)-funded public health initiatives around the world. It is a USAID program implemented by Chemonics International.

GHSC-PSM is working with USAID to explore the potential of incorporating unmanned aerial vehicles (UAVs) for moving health commodities through public health supply chains, with a goal of undertaking a pilot by the end of 2017. There are few practitioners using UAVs for cargo delivery in the development context. With the size of the project and its focus, GHSC-PSM is in a unique position to begin incorporating UAV technology.

As a first step, GHSC-PSM completed the UAV Landscape Analysis to assess the various technologies, UAV actors, regulations, pilots undertaken, and lessons learned from existing use of UAVs in the development context. This analysis is being used to inform the project's work toward a pilot project.

GHSC-PSM anticipates that incorporating UAVs into its supply chains could have significant beneficial impact on how commodities, emergency cargo and lab tests are moved around countries in the future.

The project also anticipates that the analysis will be a resource for others interested in this sector.

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LIST OF ABBREVIATIONS

AED .... Automated external defibrillator
ART .... Antiretroviral therapy
BVLOS .... Beyond visual line of sight
DBS .... Dried blood spot
DVLOS .... Digital visual line of sight
EMR .... Emergency medical response
FSD .... Swiss Foundation for Mine Action
GIS .... Geographic information system
IOM .... International Organization for Migration
LMICs .... Low- and middle-income countries
MSF .... Médecins Sans Frontières
NITAGs .... National Immunization Technical Advisory Groups
OCHA .... United Nations Office for the Coordination of Humanitarian Affairs
OHCA .... Out-of-hospital cardiac arrest
PEPFAR .... President's Emergency Plan for AIDS Relief
PNG .... Papua New Guinea
RTF .... Ready to fly
SAR .... Search and rescue
UAS .... Unmanned aircraft system
UAV .... Unmanned aerial vehicle
UNDP .... United Nations Development Program
UNFPA .... United Nations Population Fund
UNICEF .... United Nations Children's Fund
VLOS .... Visual line of sight
VTOL .... Vertical takeoff and landing
WHO .... World Health Organization

1. INTRODUCTION

A. BACKGROUND: THE GROWING USE OF UAVS IN THE DEVELOPMENT CONTEXT

The use of unmanned aerial vehicles (UAVs) in the development context is relatively new but has been growing significantly over the last three years (see Figure 1). The collection of information, such as aerial videos and photographs, is common since the simple function of carrying a sensor and remotely triggering a camera has matured sufficiently for the consumer market. Now attention has turned toward a new type of application: using UAVs to deliver items. The hopes are high that UAVs can address some of the most common health logistics challenges by circumventing problematic infrastructure on the ground, speeding up delivery processes, and making supply chains more responsive. Much media attention has been directed toward this issue, as technology companies are preparing regulators and policymakers for a future where UAVs will make deliveries of consumer goods and postal shipments. However, the most UAVs that can carry and deliver things are merely prototypes and are not yet ready for the consumer market.

A few limited tests of UAVs have taken place in the health supply chain field. Médecins Sans Frontières (MSF) paved the way in 2014 as the first humanitarian organization to test the use of UAVs to deliver sputum samples for tuberculosis testing in Papua New Guinea. The innovative trial indicated that while the UAV system needs significant improvement, it might be a useful method of connecting remote health centers to central hospitals, labs, and distribution centers in the future. Two years later, the "future" has arrived with several ongoing UAV trial programs and updated UAV technology to tackle the challenges of health supply chain delivery in hard-to-reach areas. Even though technological challenges remain — as well as restrictive regulatory issues — international organizations such as WHO, UNICEF, UNFPA, and UNDP have followed in the footsteps of MSF. On the national side, the government of Rwanda is currently in the early stages of piloting a national UAV cargo delivery system, where the delivery of emergency medical supplies is essential.

Important lessons from these early-stage projects — covering acceptability, proof of concept and rigorous testing of the technology — are currently setting the stage for improvements and the potential future expansions of UAVs in health supply chains in the development context and beyond.

B. APPLICATIONS IN THE HUMANITARIAN SECTOR

UAVs have numerous applications in the humanitarian context and direct applications and indirect applications for the public health sector more broadly.

UAVS AND THE HEALTH SUPPLY CHAIN

UAVs are evidently well equipped to access difficult terrain, which has led NGOs to consider them as a tool in the humanitarian supply chain — particularly in situations where time is critical in delivery. [1] TB testing (seen in the MSF case study below) is one example that has shown the possible time that can be saved with UAVs, but such systems could also improve the emergency response to viruses such as Lassa or Ebola, where quarantine is necessary. Cases could be quarantined in their homes while UAVs carrying samples are dispatched for testing.

UAVs also may offer a cheaper alternative to conventional aircraft where shipments of high-frequency, low-weight items are concerned. Capitalizing on this for cold chain products seems like an obvious move. Of course, the technology is the limiting factor: battery life and low payload prevent goods of reasonable size being delivered any meaningful distance. However, future developments could change this: solar-powered drones are one option, as are drones with combustion engines. There is also the possibility of UAVs that can automatically dock with charging stations (possibly solar powered) along a set route, effectively hopping from one station to the next as far as required. [2]

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[1] Robohub. *How can we use drones in the humanitarian and health sector.* http://robohub.org/how-can-we-use-drones-in-the-humanitarian-and-health-sector/ (accessed November 7, 2016).

[2] Robohub. *How can we use drones in the humanitarian and health sector.* http://robohub.org/how-can-we-use-drones-in-the-humanitarian-and-health-sector/ (accessed November 7, 2016).

UAVS IN SURVEYING

Using geo-referenced photography (or photogrammetry), UAVs are already being used to quickly survey and produce large 2D and 3D maps of astounding accuracy. The use of UAVs is becoming more common, particularly within the agriculture and construction industries. Humanitarian actors are also exploring their use in various emergency and recovery situations. The International Organization for Migration (IOM) has been using UAVs in Haiti for several years for flood mitigation and camp management; in the Philippines, MEDAIR mapped areas affected by Typhoon Haiyan; and the World Bank has funded a large-scale mapping effort of informal settlements in Tanzania. The availability of UAV-generated maps has already led to faster response during cholera outbreaks in Tanzania. [3]

As with all innovation, technology is the deciding factor on feasibility. The Swiss Foundation for Mine Action (FSD) has been exploring the use of drones in humanitarian demining contexts and for broader humanitarian applications for many years. There are many projects to mount instruments such as thermal sensors on UAVs to detect potential minefields. This seems like a reasonable goal; drones that can map radiation already exist.

UAVS IN PUBLIC HEALTH PREVENTION

Besides transportation and mapping, UAVs can be used from a public health prevention perspective, particularly in vector control. Projects in Brazil tackling Zika-carrying mosquitoes and in Ethiopia to combat the Tsetse fly are using increased maneuverability to improve the targeted use of sterile vectors to stem the spread of disease.[4] [5]

UAVS IN SEARCH AND RESCUE

In emergency response operations, UAVs can be helpful to emergency medical response (EMR) personnel because they quickly and easily provide real-time surveillance over a natural disaster area or accident scene. UAVs provide a faster and cheaper option than satellites to scan the scene from above. They can also fly under the clouds and closer to the scene, providing higher quality images. In search and rescue operations, UAVs can be equipped with heat cameras, making it possible for them to more easily track missing and injured people after a landslide, tsunami, or earthquake.

UAVS IN EMERGENCY RESPONSE

There are few medical situations where time is more valuable than during organ transplants. A heart can only survive for four to six hours outside the body, so the process of matching a recipient with the same blood type, body size, and geographic location must occur quickly. Research has shown that while there is no clear medical advantage for the victim to be transported by air ambulance versus ground ambulance, air evacuation does provide more viable organs than traditional ground units. Could drones offer paramedics on the scene a tool to harvest and send organs on par with the system of getting the organs to the hospital by air?

Cardiac arrest is another situation where time is of the essence. In cases where defibrillation is the only option for revival, drones might again provide a swift transportation option. As explored in one of the case studies below, the possibility of UAVs arriving on the scene with a defibrillator attached is already under consideration.

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[3] FSD. *UAV case studies.* http://drones.fsd.ch/en/tag/case-study/ (accessed on November 30, 2016).

[4] Prefeitura de Vitoria. *Zika: Prefeitura usa drones no combate aos focos do mosquito.* http://www.vitoria.es.gov.br/noticia/zika-prefeitura-usa-drones-no-combate-aos-focos-do-mosquito-19703 (accessed November 7, 2016).

[5] The UAE Drones for Good Awards. *Drones in support of sustainable rural development in Ethiopia.* https://dronesforgood.ae/finals/drones-support-sustainable-rural-development-ethiopia (accessed November 6, 2016).

Figure 1: Map showing the locations of known humanitarian UAV projects. The data come from UAViators and can be viewed in detail in Annex 1, or as an interactive map at: https://www.google.com/maps/d/viewer?mid=1wdligD6V9KZFd_vaCOVGA_Rn-ll&ll=5.140328190247929%2C-16.071904899999907&z=3

C. THE UAV LANDSCAPE ANALYSIS

Unmanned Aerial Vehicles Landscape Analysis: Applications in the Development Context is a comprehensive, in-depth investigation of the potential and limitations of using drones for development with an emphasis on health supply chains. It summarizes the findings of UAV and health supply chain researchers, stakeholder consultations, and case study analysis of field deployments. The analysis includes an assessment of the sector over the last three years, successful cases, and key challenges and gaps. The aim of the investigation is to provide a foundation of background knowledge for actors interested in exploring the use of UAVs in health supply chains in a development context and beyond.

D. SCOPE OF WORK AND METHODOLOGY

GLOBHE carried out a UAV situation analysis and UAV mapping analysis, involving a critical review of UAVs in a development and health supply chain context. This included:

- An assessment of the sector over the last three years;
- Identification of factors that contributed to the achievement of the positive results recorded;
- Analysis of the strengths, weaknesses, opportunities, and challenges of UAVs in a development and health supply chain context; and
- Identification of the key gaps that require exploration in the future.

The mapping analysis employed both a literature review and a collection of previous experiences from those involved in writing the report, as well as consultations with cargo UAV providers such as Matternet and Zipline and international organizations currently using cargo UAVs such as UNICEF and MSF. In most sectors, it was possible to refer to these actors as "market leaders"; however we feel it is important to highlight that, in the current discourse, it is too early to identify any of these companies as such. To do so risks marginalizing many qualified companies that have not yet engaged with the market.

A detailed analysis of existing cases and literature identified the successes and challenges for a list of key case studies. These were then collated to highlight recurring themes across this fast-moving sector. Strategic focus and programs are proposed based on the synthesized successes, gaps, challenges and issues.

GLOBHE identified opportunities for UAVs in the health supply chain by looking at key elements including, but not limited to:

- UAV Technology:
  - Types, capabilities, and past and ongoing field tests
- Application:
  - Interest (Why is drone delivery being considered?)
  - Problems
  - Project goals and objectives
- Payload:
  - Description and type (especially high-impact, low-weight, cold chain goods, e.g., medicine, diagnostics, stat specimens, spare parts, transfusion blood, anti-venom, etc.)
  - Weight
  - Volume
  - Dimensions of shipment
  - Value
  - Special handling requirements (e.g., temperature, vibration tolerance, etc.)
  - Other special characteristics
- Location:
  - General area/location
  - Ground experience, knowledge, and presence at project locations
  - Conditions (e.g., electricity, Internet connectivity, staff on site, cellular connectivity, etc.)
  - Days and hours of operation
  - Staffing at sites
  - Proposed takeoff and landing locations
  - Restrictions
- Distances:
  - Road distance between sites vs. direct distance between sites
- Frequency:
  - Number of shipments per hour
  - Number of shipments per day
  - Number of shipments per week
  - Urgency
- Current Solution:
  - How is the item currently transported?
  - What are the costs (direct and indirect)?
  - How much time does current transportation take?
  - What is the reliability?
  - What are the pain points?
- Budget:
  - Budget and duration
  - Timeline
  - Decision-makers
  - Opportunities for expanded work

E. WORKFLOW AND EXPECTED RESULTS

GLOBHE conducted the UAV Landscape Analysis by analyzing a number of key case using a desk study approach of relevant UAV research reports and articles, conducting stakeholder consultations, and obtaining feedback from field deployments.

The selection and demarcation of relevant key case studies was done primarily based on theme (UAV case studies relevant to health supply chains and, preferably, diagnostic services) and secondarily based on geography (UAV case studies relevant to a development context and, if possible, in a President's Emergency Plan for AIDS Relief [PEPFAR] focus country or region). In addition, projects considered too basic (i.e., prototype testing in test environments) were not selected as key case studies.

Six case studies passed the selection criteria and underwent further analysis. Four of the selected studies (Madagascar, Malawi, Papua New Guinea, and Rwanda) fulfill both the thematic and geographical criteria and have been determined to be the only "substantial" cases existing at the time of writing (November 2016). The other two key case studies (Sweden and Maldives) were selected for thematic relevance (Sweden) and potentially thematic relevance (Maldives).

Based on the findings of the case studies, a problem analysis was carried out, and for selected key case studies, relevant data for landscape analysis were gathered and reviewed for a structured explanation of the key lessons. GLOBHE applied helpful tools such as the SWOT model and cost-benefit models when applicable.

To successfully analyze the degree of success specifically within health supply chains, a broader knowledge foundation needs to be adopted, including a change management perspective to analyze what is required from surrounding elements and factors affecting the supply chain. The work will result in a UAV Landscape Analysis report describing the potential and limitations of UAVs in health supply chains in a development context.

The methodology, workflow, and expected results are presented in Figure 2.

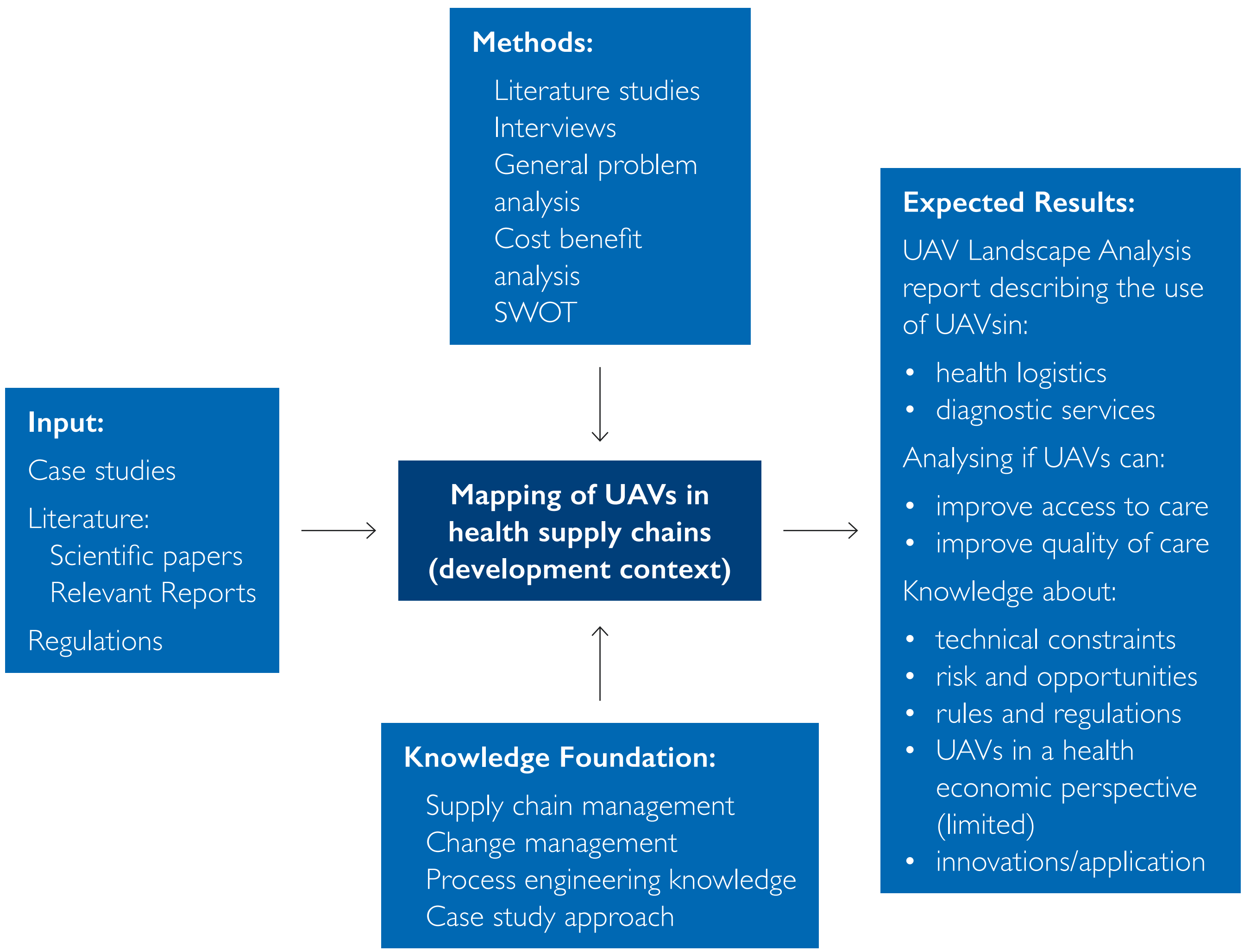

Figure 2: Methodology, Workflow, and Expected Results

The expected results include the idea that UAVs have the potential to improve access to essential medicine in hard-to-reach areas, speed up transportation of medicine and medical supplies, provide access to faster diagnostic services, and complement existing health supply chains. As to where this will lie on the cost-analysis scale, it is difficult to quantify with the limited data available, but it is expected that programs that have now started will be able to provide a comparable, or cheaper, option than traditional deliveries. In addition, UAV technology potentially reduces the need for endless training on forecasting. If the delivery system is a text message away via a drone delivery, no one needs to forecast; they request amounts/deliveries daily. However, regulatory limitations and technical constraints currently limit the full potential from a health supply chain perspective. Further cost analysis of health economics will likely be needed, as well as analysis of risk and opportunities and of innovations and applications.

II. TECHNOLOGY, ACTORS, AND REGULATIONS

A. UAV TYPES AND TECHNOLOGY

To date, the majority of UAVs used in health supply chain delivery have been small or mini-sized devices weighing approximately 5-15 kg. These models are prototypes, not yet available on the market and limited in flight range and time by power capacity and battery size. Models are developed with ease of use and safety in mind, but field experience has shown that the existing technology usually requires several staff from the developing company to be on site for set up, piloting, and trouble-shooting. It should be assumed that to ensure local capacity, extensive training would be necessary, as UAVs need to be both operated safely and maintained. Many of the companies that are currently developing UAVs with cargo capacity are start-ups or businesses that specialize in manufacturing consumer UAVs.

Long-range aircraft-sized UAVs have not been used for humanitarian and health supply chain purposes, possibly because this technology remains in the military domain. It is believed that companies such as Boeing, Lockheed Martin, Northrup Grumman and others would have technology that is far more advanced than many of the companies known today, but they have not yet entered the civilian market. The association with military interventions has also been a deterrent for organizations such as MSF, which fiercely guards its neutrality among actors in combat zones, choosing to limit UAV use to projects in stable contexts.[6]

The technology and operationalization of UAVs for cargo delivery is still in the development phase and much is likely to happen over the next five years. Many of the companies that are based in Europe or the United States that are developing cargo UAVs have already sought or are seeking to first operationalize their technology in development contexts, possibly due to less stringent regulations. There is a fair degree of criticism of that approach, as it is understood that many companies are starting to operationalize in a development context to provide a proof of concept or gain a competitive advantage by gaining experience with prototypes before entering more regulated European and United States airspace. Some of the known actors that have tested cargo UAVs in Europe or the United States without forming development partnerships are Amazon, Google, DHL and Microdrones, as of November 2016. At the same time, some start-ups are building models specifically to address the unique challenges (e.g., limited infrastructure, limited possibilities for storing of medicine, limited investment capacities) that are encountered in the developing world. Examples include Dr. One, UAVaid, Wings for Aid and Drones for Development.

B. UAV TYPES: FIXED-WING, MULTI-ROTOR AND HYBRID

There are primarily three types of UAVs used in health supply chain delivery: fixed-wing drones, multi-rotor drones, and hybrid drones. The most suitable drone type depends on the application, environmental conditions, regulatory framework, organizational needs, associated cost, and supporting infrastructure, among other considerations. In this section, we will explore the suitability of each drone type in different contexts.

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[6] MSF. *Drone aid: a useful tool with a toxic image.* http://msf-analysis.org/drone-aid-a-useful-tool-with-a-toxic-image/ (Accessed November 3, 2016).

Regardless of their type, the majority of UAVs fly by autopilot, following predetermined flight paths and using GPS for orientation. A pilot monitors the flight progress and makes suitable adjustments when necessary. The UAVs may have built-in sensors for avoiding obstacles and built-in safety measures such as parachutes in case of a fault. Safety measures and systems are of utmost importance in the cargo UAV fields, as craft usually need to operate beyond the visual line of sight, often fly over inhabited areas, and may carry dangerous goods.

FIXED-WING UAVS

Fixed-wing drones, with two wings and the design of a small airplane, are typically used to cover longer distances and carry heavier payload. Typically, the fixed-wing drone can fly at speeds around 100 km/hour and cover a round trip of 150 km, operating in up to 50 km/hour winds. Normally the payload ability varies from 1.5-4.5 kg. Fixed-wing drones (see Picture 1) are suitable for transportation of cargo over longer distances, making them suitable for health supply chain delivery. A major drawback of fixed-wing drones is that they are not designed for vertical takeoff and landing (VTOL) and often require a landing strip of open space approximately equivalent to a soccer field/two parking lots. This means they are less suitable to pick up samples for diagnostic services and are instead better for air-drop/parachute delivery of emergency medical supplies to health centers in hard-to-reach areas.

Picture 1: Fixed-wing UAV | JoeB52 | Creative Commons

Picture 2: Multi-rotor UAV | Capricorn4049 | Creative Commons

MULTI-ROTOR UAVS

Multi-rotor drones are mostly used for shorter flight times and shorter distances, for instance to record films/pictures for stakeholders such as search and rescue (SAR) teams or to transport lighter cargo. The most common design is the multi-rotor drone with four propellers, the quad-copter drone. Models with one rotor (helicopter) and up to eight rotors (octo-copters) also exist. The main advantage of the multi-rotor drone is its ability to take off and land vertically, making it suitable not only for delivering but also for picking up samples to improve diagnostic services. The main drawback is that flight time and therefore distance is severely shortened. However, recent technology updates now enable distances of up to 20 km (round trip) with a payload of 2 kg. The UAVs can operate in a network structure with a replacement of battery at designated posts or health clinics to cover greater distance. Multi-rotor drones can be operated using smart phones, tablets, or regular PCs and follow pre-determined GPS routes.

HYBRID UAVS

Hybrid drones are a new but promising concept, as they are equipped with both wings and rotors which allow for vertical takeoff and landing (like the multi-rotor drone) as well horizontal flight like fixed-wing drones. This makes it possible to cover longer distances and carry heavier cargo than multi-rotor drones. Similar software applications are available for hybrid drones as for fixed-wing and multi-rotor drones.

Picture 3: Hybrid UAV | Taken from: https://latitudeengineering.com/

Table 1: comparative merits of different uav technology used for the delivery of cargo

	Fixed wing	Multi-rotor	Hybrid
Range	Up to160 km	About 20 km	About 80 km
Payload	Up to 5 kg	Up to 2 kg	Up to 5 kg
Launch	Catapult	Vertical	Vertical
Variations	Gas or electric	Gas or electric	Gas or electric
Advantages	• Long range • More efficient • Heavier payloads than multi-rotor • More stable flying • Well established concept with the weight of aerospace engineering behind it	• Maneuverability in small spaces • Vertical takeoff and landing • Generally cheaper • Can fly with a minimum of two rotors	• Vertical take-off and landing but with comparable range to fixed wing • More options for landing and take-off sites • Heavier payloads than multi-rotor • Easier for "safe" emergency landings
Disadvantages	• Large space required for take-off and landing (no VTOL) • Limited maneuverability in small spaces • Emergency landings are generally less easy to control	• Low payload limit • Generally more complex designs (high software requirements to keep in the air) requiring expert maintenance and trained staff at health centers • Limited range • Inefficient in some settings	• Generally more expensive • Neither as long range as fixed wing nor as maneuverable as multi-rotor
Manufacturers	• Zipline • Wings for Aid • UAVaid	• Matternet • Flirtey • Microdrones	• Amazon • Google • DHL • Drones for Development - Dr. One. • Quantum Systems • Vayu
Example of Users	• Government of Rwanda • MOAS	• MSF • World Bank • UNICEF • Swiss Post	• MSF (planned) • We Robotics (planned)

C. COMMERCIAL DRONE PROJECTS

AMAZON

Country	US, UK, Austria, and Israel
Actors	Amazon Prime Air
UAV technology	Hybrid and multi-rotor
Payload	Unknown
Date of operation	Ongoing (prototype stage)
Distances	10 miles+
Frequency	Unknown
Goal of project	Commercial drone deliveries

Amazon Prime Air is a future service that will deliver packages up to five pounds in 30 minutes or less using small drones. Flying under 400 feet elevation and weighing less than 55 pounds, Prime Air vehicles will take advantage of sophisticated "sense and avoid" technology, as well as a high degree of automation, to safely operate beyond the line of sight to distances of 10 miles or more (when and where Amazon has the regulatory support needed). Amazon has Prime Air development centers in the United States, the United Kingdom, Austria, and Israel. The company is testing the vehicles in multiple international locations.[7]

DHL

Country	Germany
Actors	DHL Parcel
UAV technology	Tiltwing aircraft and quadrocopter
Payload	Unknown
Date of operation	January-March 2016
Distances	Unknown
Frequency	130 deliveries
Goal of project	Commercial drone deliveries

DHL Parcel has successfully concluded a three-month test of its third Parcelcopter generation. The trial run, part of a larger research and innovation project, was conducted between January and March 2016 in the Bavarian community of Reit im Winkl. It represents the first time worldwide that a parcel service provider has directly integrated a parcelcopter logistically into its delivery chain. Private customers in Reit im Winkl and on the Winklmoosalm Plateau were invited to test out the specially developed Packstations, dubbed Parcelcopter Skyports. During the three-month trial period, they could simply insert their shipments into the Skyport to initiate automated shipment and delivery via Parcelcopter. A total of 130 autonomous loading and offloading cycles were ultimately performed.[8]

GOOGLE

Country	United States
Actors	Google X
UAV technology	Hybrid
Payload	Unknown
Date of operation	August 2016
Distances	Unknown
Frequency	Unknown
Goal of project	Commercial drone deliveries

Google's parent company, Alphabet, plans to make commercial drone deliveries by 2017 as part of Project Wing. Google X, the division of Alphabet responsible for Project Wing, received approval from the White House in August 2016 to test Project Wing at a U.S. site. The drones will be tested at one of the six sites approved by the Federal Aviation Administration (FAA).[9]

[7] Amazon. *Amazon Prime Air.* https://www.amazon.com/b?node=8037720011 (accessed November 4, 2016).

[8] DHL. *Successful Trial Integration of DHL Parcelcopter into Logistics Chain.* http://www.dhl.com/en/press/releases/releases_2016/all/parcel_ecommerce/successful_trial_integration_dhl_parcelcopter_logistics_chain.html (accessed November 6, 2016).

[9] Business Insider. *Google's secretive drone delivery project gets go ahead.* http://www.businessinsider.com/google-project-wing-drone-service-2016-8?r=US&IR=T&IR=T (accessed November 6, 2016).

FLIRTEY

Country	United States
Actors	NASA, Virginia Tech University, Flirtey
UAV technology	Multi-rotor
Payload	4.5 kg
Date of operation	July 2015
Distances	Up to 16 km
Frequency	Unknown
Goal of project	Transportation of medical supplies to rural health clinic

The first federally approved drone delivery in the United States took place in July 2015 and was conducted by an Australian startup, Flirtey, delivering medical supplies to a rural health clinic in Virginia. The Federal Aviation Administration approved Flirtey to make the delivery as part of a joint venture between NASA, Virginia Tech University, and several health care organizations in Virginia called "Let's Fly Wisely."[10]

SWISS POST, SWISS WORLDCARGO, AND MATTERNET

Country	Switzerland
Actors	Swiss Post, Swiss Airlines, and Matternet
UAV technology	Multi-rotor
Payload	Unknown
Date of operation	July 2015-present
Distances	Unknown
Frequency	Unknown
Goal of project	Commercial delivery

Swiss Post, Swiss WorldCargo and Matternet are jointly testing the commercial use of logistics drones. The three companies are investigating specific uses of drone technology and examining the cost-effectiveness of these business ideas. The first tests were carried out in July 2015 for this purpose. The widespread use of drones is not expected within the next five years. The focus is primarily on their use in exceptional cases or the transport of special items.[11]

D. UAV ACTORS AND PARTNERSHIPS IN THE HUMANITARIAN SECTOR

To date, few organizations that have used UAVs in humanitarian programs have developed their own internal capacity.[12] Instead, most humanitarian organizations have been working with UAV companies (Matternet, Zipline, and DJI, to name but a few) or in partnership with other actors capable of UAV deployments. Complementing this, UAViators works to promote safe, coordinated, and effective use of UAVs and has developed a comprehensive code of conduct (see Annex 2) that can be used as a guide to organizations interested in exploring the use of UAVs. The Humanitarian UAV Network and WeRobotics seek to develop local flying labs for personnel training purposes.

During the development phase of UAVs in humanitarian projects, it has been quite common for UAV companies to provide their technology free of charge to humanitarian organizations and/or local ministries/governments for them to test their solutions and perfect their technology in field conditions and in countries where regulations are more favorable compared to the "home market." Some partnerships that have been established in regards to health supply chains in a development context are:

- Matternet and MSF in Papua New Guinea
- Matternet and WHO in Bhutan
- Matternet, UNICEF, and the Malawi Ministry of Health
- Matternet and the Inter-American Development Bank (to be implemented in Dominican Republic)
- Zipline, government of Rwanda, GAVI, and UPS
- Vayu, Stony Brook University, the government of Madagascar, and USAID

[10] Fortune. *Drone makes first legal doorstep delivery in milestone flight.* http://fortune.com/2015/07/17/faa-drone-delivery-amazon (accessed November 7, 2016).

[11] Swiss Post. *Swiss Post, Swiss WorldCargo and Matternet start drone tests.* https://www.post.ch/en/about-us/company/media/press-releases/2015/swiss-post-swiss-worldcargo-and-matternet-start-drone-tests (accessed November 7, 2016).

[12] FSD. *Drones in Humanitarian Action: A Guide to the Use of Airborne Systems in Humanitarian Crises.* (Unpublished version. Published version available December 2, 2016). http://drones.fsd.ch/wp-content/uploads/2016/11/Drones-in-Humanitarian-Action.pdf

- DJI, UNDP, and government of Maldives
- WeRobotics, Humanitarian UAV Network, and Vayu (to be implemented in Nepal)
- Stork and Ifakara Health Institute, with funding from Human Development Innovation Fund and Saving Lives at Birth Grand Challenge

E. UAV REGULATIONS

UAV regulations differ from country to country, and even within countries. Currently, regulatory frameworks present a big challenge for the UAV sector for both commercial and humanitarian purposes. Regulations stating that UAVs have to fly within visual line of sight (VLOS) of the operator limit the distance and potential of using UAVs in health supply chain delivery. Countries that do allow UAVs to fly autonomously from point A to point B — outside VLOS — allow the opening up of further uses and applications of UAVs, not least from a health supply chain perspective. Some regulations permit cargo delivery, but not dropped or parachuted items. Regulators might provide special permits for humanitarian purposes, and permissions for beyond visual line of sight (BVLOS) can be applied for (depending on the country), but this tends to be a long and complicated process. There are some ongoing developments in digital vision line of sight (DVLOS), where digital cameras are being used to keep the UAVs in line of sight, which potentially can serve as an alternative.

If no regulatory changes are made, the application of cargo drones will be limited on a global scale. Currently, regulations in Europe and the United States greatly limit the use of cargo drones based on security and aviation fears, while some countries in sub-Saharan Africa have opened themselves up for such applications. Rwanda has put itself at the forefront and aims to be the first country in the world with a nationwide UAV delivery network, with health supply chain delivery at its core.

In the spring of 2016, Rwanda launched a national UAV regulation framework, making it possible to coordinate the safe use of UAVs in the country. Other countries have started to follow but seem to be more restrictive, such as Uganda, where the UAV regulatory system has been made very complex, or Kenya, where UAVs were until recently forbidden for security reasons. Humanitarian and development actors may be able to obtain special permits by engaging directly with government actors. Overall, many of the countries where humanitarians are working still lack legal UAV frameworks, meaning that the use of UAVs will probably need to be cleared on an ad hoc basis with local and national authorities.[13] This can create opportunities but also problems if not carefully coordinated.

In general, a local partner entity that is familiar with national procedures should handle the processes of obtaining permits. Even where regulations do not exist, governments and national authorities should be fully informed about projects that use UAVs. The amount of time that is required from first engagement varies greatly, and usually several actors are involved. If there is a precedent of use of similar UAV technology without incident in the country, the process to obtain permits tends to be smoother. If, on the other hand, the technology is unknown or without precedence, obtaining permits may take months to a year, flight paths may need to be adjusted, or, in some cases, permission to fly may not be granted at all.

The International Civil Aviation Organization (ICAO), the regulating body responsible for international aviation, does not yet stipulate regulations for autonomous or low-level operations but only for cross-border operations.[14] This has resulted in member states formulating their own regulations, creating a situation that leads to a lack of standardization across countries.[15] A repository of information on country regulations is available at www.uavregulations.info.

F. PERCEPTION OF UAVS

One of the main concerns regarding the use of UAVs in the development context is perception of their use among local populations. In a recent study, 57 percent

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13 OCHA. *Unmanned Aerial Vehicles in Humanitarian Response.* OCHA Political Studies Series 10. June 2014. https://docs.unocha.org/sites/dms/Documents/Unmanned%20Aerial%20Vehicles%20in%20Humanitarian%20Response%20OCHA%20July%202014.pdf

14 FSD. *Drones in Humanitarian Action: A Guide to the Use of Airborne Systems in Humanitarian Crises.* (Unpublished version. Published version available December 2, 2016).

15 FSD. Regulations Session. *Summary Report. Cargo Drones in Humanitarian Action.* Meeting Summary. 2016.

of queried humanitarian aid workers (in a global survey of humanitarian aid activities implemented with the financial assistance of the European Union) believe that local communities would feel threatened by the use of UAVs.[16] However, evidence from many projects that have used UAVs for mapping in Nepal, the Philippines, Haiti, Tajikistan, Malawi, and Tanzania have shown that communities were not fearful; in fact, communities often embraced the technology.[17] A study on perceptions conducted by FHI 360 following the use of mapping UAVs over Dar es Salaam found that citizen witnesses and government officials were overwhelmingly positive about the potential of UAV technology in Tanzania.[18] However in all instances, local communities and governments were fully involved and informed about the UAV work that was being conducted, and the technology was deployed with a clear use in mind.

UAV use in active conflict is a contentious subject, and not much experience is available for civilian uses of UAVs in such areas. Most uses are limited to media and advocacy work that used aerial filming and photographs.[19] UAVs have never been used to deliver aid in conflict zones so far, and many humanitarian actors strongly oppose the use of UAVs in this context.

There is a particular concern that stakeholders in conflict areas will see any flying object there as potentially hostile, which may instill unnecessary fear or even escalate a conflict. For this reason, MSF has rejected UAV use in conflict zones.[20] This cautious approach might seem rational, yet we know of no hostility in existing cases of UAV use in conflict zones.

More generally, local populations have widely accepted the use of UAVs to date. It could be that there has been a push to ensure local education before and during project implementation that has resulted in this positive attitude.

[16] FSD. *Drones in Humanitarian Action – A survey on perceptions and applications.* 2016.

[17] FSD. *UAV case studies.* http://drones.fsd.ch (accessed October 30, 2016).

[18] FHI 360. *Using Unmanned Aerial Vehicles for Development: Perspectives from Citizens and Government Officials in Tanzania.* http://www.ictworks.org/wp-content/uploads/2016/02/UAV-public-perceptions-tanzania.pdf (accessed November 4, 2016).

[19] Al Jazeera. *ICRC camera drone captures damage in Ramadi.* http://www.aljazeera.com/news/2016/07/iraq-icrc-camera-drone-captures-damage-ramadi-160705052624718.html (accessed November 4, 2016).

[20] Robohub. *How can we use drones in the humanitarian and health sector.* http://robohub.org/how-can-we-use-drones-in-the-humanitarian-and-health-sector/ (accessed November 7, 2016).

Table 2: current laws and regulations in relation to the use of uavs in pepfar countries[21, 22]

Country	Current laws and regulations for the use of UAVs in pepfar countries
Angola	No specific regulations are currently known.
Antigua and Barbuda	No specific regulations are currently known.
Bahamas	A registration plate is required on all remotely piloted aircraft. Draft regulations were issued in April 2015 and are expected to be implemented in 2015.
Belize	Authorizations from the Belize Department of Civil Aviation (BDCA) need to be sought prior to UAV flights.
Botswana	• New regulations for operating drones in Botswana became effective from July 2, 2015. • All drones must be registered with the CAAB (Civil Aviation Authority of Botswana), including those for private use. • The following regulations apply to the operation of UAVs for private use only, with a Maximum All Weight Up (MAUW) of 20 kg and are limited to VLOS operations. - The remote piloted aircraft (RPA) shall not be flown unless the operator is present. - The operator will at all times maintain VLOS with the RPA. This will be accomplished unaided by any device other than corrective lenses. - RPA will be flown below 400 ft above ground level (AGL) at all times and no further than 500 m from the operator at the controls of the RPA. - The operator may make use of a visual observer (VO). - The operator or the VO may not fly more than one RPA at any one time. - The RPA registered in Botswana is not permitted to cross international boundaries. - No person shall operate an RPA unless they have in their possession the certificate issued by the authority for each RPA in operation and the user manual for the RPA.
Burma (Myanmar)	• No formal laws exist, but anti-espionage and reconnaissance regulations could potentially affect drone users. • Burmese drone users report having equipment confiscated. Importing some radio-controlled equipment is not permitted. • Local authorities sometimes give permission for flights.
Burundi	No specific regulations are currently known.
Cambodia	• Flying drones is banned in the Cambodian capital of Phnom Penh. In cases where their use is considered necessary, permission must first be obtained from City Hall authorities. • The ban applies to both private and commercial use but should be understood as a regulation, and not as an outright prohibition on drone use. The sale and purchase of drone technology are still legal in the capital. • Drone usage in Cambodia outside of the capital remains legal and unregulated for now.
Cameroon	No specific regulations are currently known.
China	• Secondary sources indicate that any individual who wishes to operate a UAV weighing more than 7 kg must obtain a license. • Any individual wishing to operate a UAV weighing more than 116 kg and operating in an integrated airspace, where manned aircraft also fly, must have a pilot's license and a UAV certification. • Operation of a UAV in a manned area requires prior approval.
Costa Rica	Drones are being used for research but no information on regulations could be found.
Côte d'Ivoire	No specific regulations are currently known.

[21] Taken from http://www.uavregulations.info (publicly available from November 15, 2016).

[22] Regulatory information on Ghana and Kenya was taken from http://wiki.uaviators.org (accessed November 7, 2016).

Country	Current laws and regulations for the use of UAVs in pepfar countries
Dem. Rep. of the Congo	There are currently no national laws on drones.
Dominica	Member of Organization of Eastern Caribbean States. Regulations determined by Eastern Caribbean Civil Aviation Authority. The ECCAA is not known to have established regulations on the usage of civilian drones at this time.
Dominican Republic	Matternet has been testing drones for development use, but no regulation information could be found.
El Salvador	No specific regulations are currently known.
Ethiopia	Nothing was found outside the military's use of UAVs.
Ghana	• The Ghana Civil Aviation Authority (GCAA) is set to issue new directives on the requirements for the registration and use of drones in Ghana. • The drones, which are technically known as "remotely piloted aircraft systems," are, among other things, meant to serve as a directive to supplement the provisions of the Ghana Civil Aviation (Safety) Regulations, 2011, L.I. 2000. • Regulations ensure safety in the operations of the remotely piloted aircraft system (RPAS). • Among some of the obligations under the new directives, personnel will not be obliged to act as an RPA observer without having in his/her possession proof of RPA observer competency issued by a training organization approved by the authority. • Meanwhile, some privileges and conditions included are: no person shall operate an RPAS without a license issued by the authority. No RPAS pilot shall operate an RPAS except in accordance with the ratings, limitations or endorsements of their license. The exercise of the privileges granted by a remote pilot license shall depend on the validity of the license, the medical certificate and, if applicable, of the ratings contained in the license. An RPAS piloting license shall be valid for a period of five years, renewable every year upon proof of a valid medical certificate. According to the GCAA, more on the initial directives could be assessed on their website under the heading, "Safety Directives on Remotely Piloted Aircraft System (RPAS)." • GCAA will be holding a stakeholders conference in spring 2017 to finalize the new directives.
Grenada	No specific regulations are currently known.
Guatemala	No specific regulations are currently known.
Guyana	Operating restrictions apply to recreational drone flights: • Do not fly at a height exceeding 400 ft. • Do not fly beyond a range of 1600 ft from the person controlling the device. • Do not operate over an open air assembly of people with the exception of over the person in control. • Do not fly over or within 150 ft of any other person. • Do not operate over or near a private or public property without prior permission from the owner. • Do not operate within five miles of any airport/airstrip/helipad and/or landing pad. • Do not operate at night or in low visibility conditions. • Do not drop or tow any object during flight. • Keep aircraft within visual line of sight at all times. • Fly clear of obstructions. • Do not fly with a first-person view device. • Do not operate in a reckless and unsafe manner to endanger persons and/or property. • Professionals (commercial and non-commercial) are described as persons or companies that operate unmanned aerial vehicles (UAVs) for non-recreational purposes, including business-related activities such as, but not limited to, aerial photography, surveillance, geometric surveys, power line inspections, crop observations, and research and development. • Additionally, prior to commencing operation, all operators in this category must apply to the GCAA in writing for approval, providing all details of the intended operation, and should not commence operation unless written permission is obtained.
Haiti	No UAV laws or regulations are known for Haiti at this time. Contacting the Eastern Caribbean Civil Aviation Authority is recommended before flying in the country.

Country	Current laws and regulations for the use of UAVs in pepfar countries
Honduras	No specific regulations are currently known.
India	Draft regulations are summarized as follows: • All unmanned aircraft intended to be operated in India will require a unique identification number (UIN) issued from Directorate of General Civil Aviation (DGCA). The UIN can be granted only to a citizen of India or a company or a body corporate provided that: A. It is registered and has its principal place of business within India; B. Its chairman and at least two-thirds of its directors are citizens of India; and, C. Its substantial ownership and effective control are vested in Indian nationals. • The following documents are required to be submitted to DGCA for issue of UIN: A. Address of operator along with contact details with valid identity proof. In case of a company/ organization, TIN number will be accepted; B. Purpose of operation of UAV; C. Specification of UAS (manufacturer name, type, model number, year of manufacture, weight and size, type of propulsion system, flying capabilities in terms of maximum endurance, range and height, etc. including details of equipment); D. Verification of character and antecedents of the operator and remote pilots from local sub-divisional police office; E. Permission for all frequencies used in UAS operations from the Department of Telecommunication (Wireless Planning and Coordination Wing); F. Copy of Unmanned Aircraft Flight Manual (UAFM); and G. Copy of manufacturer's maintenance guidelines for UAS. • The identification plate (made of fireproof material) inscribed with UIN and RFID tag or SIM shall be affixed to the UA and appropriate makes to identify ownership. • All civil UA operations at or above 200 ft above ground level in uncontrolled airspace for any purpose whatsoever will require a UA operator permit UAOP from DGCA. • Operation of civil UA in controlled airspace is restricted. • The following entities will not require UAOP from DGCA: A. Civil UA operations below 200 ft above ground level in uncontrolled airspace and clear of notified prohibited, restricted and danger areas as well as Temporary Segregated Areas (TSA) and Temporary Reserved Areas (TRA). In addition, the operator shall obtain permission from local administration, the concerned ADC. B. Model aircraft operating below 200 ft above ground level in uncontrolled airspace & indoor UA for recreational purposes only. (Aero modeling activities carried out within the premises of educational institutions will be considered as recreational purposes).
Indonesia	UAVs are being used by the government in numerous settings (primarily for military and, recently, poaching observations) but no formal regulations could be found.
Jamaica	• Flight Safety Notification FSN-GN-2015-01 Revision 1, Apr 20, 2015 • Flight Safety Notification General Operations of Unmanned Aerial Vehicles "These guidelines apply to all persons who operate Unmanned Aerial Vehicles, including: A. Recreational or Hobbyists: Persons who operate model aircraft or Unmanned Aerial Vehicles solely for recreational purposes. B. Professional (commercial and non-commercial) operators: Persons or companies that operate Unmanned Aerial Vehicles for any non-recreational purpose, including business-related activities such as, but not limited to, aerial photography, surveillance, geometric surveys, power line inspections, crop observations and research and development activities. N.B. - Item 2 requires Special Aerial Work Permits, which are granted by the Jamaica Civil Aviation Authority (JCAA), subject to the operators meeting specific criteria."

Country	Current laws and regulations for the use of UAVs in pepfar countries
Kenya	In March 2016, the CAA released draft regulations on the use of UAVs in Kenya for public review. • RPAS will be classified in three categories determined by their weight, including payload (Class 1: <5 kg; Class 2: 5-25 kg; Class 3: >25 kg) and three use categories (Category A: sports and recreation; Category B: private activities excluding sports and recreation; and Category C: commercial activities). • Only Kenyan citizens above the age of 18 are eligible to own RPAS, and all RPAS operators or owners shall be registered. • RPAS operators shall obtain an operating certificate issued by the authority. • Operators and owners are responsible for components that are in working order and the authority may require certain classes and categories to obtain a certificate of airworthiness. • Operators are responsible for safe conduct and compliance with regulations. • It is prohibited to use RPAS a) in a manner that endangers other aircraft, persons or property, b) in prohibited areas, or c) in restricted areas unless permission has been granted by the authorities. • A person shall not operate an RPAS above 400 ft. AGL for private or recreational uses. • A person shall not operate RPAS in conditions other than visual meteorological conditions (VMC) or at night. • RPAS operated beyond visual line of sight need to be equipped with a sense-and-avoid mechanism. • Operators need to be covered by third-party risk insurance. • Prior to any operations, authorization must be sought from the authority. • In the meantime, it should be noted that operation of all aircraft within Kenyan airspace or at any point in Kenya is subject to regulatory approval and/or authorizations by the Kenya Civil Aviation Authority. • It is hereby noted that, with immediate effect, all institutions/entities or individuals intending to procure, test or operate Remotely Piloted Aircraft must: a. Seek approval from the Ministry of Defense. b. Obtain authorization from Kenya Civil Aviation Authority. • It should be noted that authorizations to operate remotely piloted aircraft will only be considered by the authority following approvals by the Ministry of Defense.
Khazakhstan	No specific regulations are currently known.
kyrgyz Republic	No specific regulations are currently known.
Laos	No specific regulations are currently known.
Lesotho	No specific regulations are currently known.
Malawi	There are no drone-specific regulations in Malawi.
Mozambique	No specific regulations are currently known.
Namibia	As of May 2015, the Namibian Directorate of Civil Aviation reported it was at an "advanced" stage of preparation for the release of regulations pertaining to UAVs. • The proposed regulations, per allAfrica.com, follow. Operating a UAV without the prior approval of the director and under conditions determined by the director is prohibited if: a) the UAV is flown higher than 150 ft above the surface; b) the UAV is flown within a published controlled zone, air traffic zone or air traffic area; and c) the UAV is flown closer than 5 nautical miles from the boundary of an aerodrome.
Nicaragua	In November 2014, the Nicaraguan Institute of Civil Aeronautics (INAC) issued a statement prohibiting the use of UAVs in national airspace. • UAV use is prohibited above 100 ft of altitude and more than 30 m from the operator in horizontal distance. • UAV use is prohibited around civil and military helicopters, and domestic or international aviation. • A permit is needed to bring a UAV into the country. Otherwise your drone will be confiscated and you will be charged a fee for keeping it in storage. INAC has said that there is no UAV use in the country, so chances of obtaining a permit are small.

Country	Current laws and regulations for the use of UAVs in pepfar countries
Nigeria	• On May 9, 2016, the Nigerian Civil Aviation Authority (NCCA) issued safety guidelines for drone operators, who will need to obtain permits from the NCAA as well as from the Office of the National Security Adviser (ONSA). • In addition, when a foreign operator wishes to apply to operate RPA in Nigeria, he/she shall make such application to the authority in the form and manner prescribed by the authority. • An application for approval to operate in the territory of Nigeria shall be accompanied by a copy of the following, in English translation if the original documents are not in the English language, for each RPA proposed to be operated in Nigeria: 1. Certified true copy of a valid RPAS operator certificate; 2. Certificate of aircraft registration; 3. Certificate of airworthiness; 4. Remote pilot(s) license and medical certificate(s); 5. Aircraft radio station license, if applicable; 6. Insurance certificate; 7. Noise certificate issued in accordance with ICAO Annex 16; 8. Aircraft operator security program; and 9. Any other document the authority considers necessary to ensure that the intended operations will be conducted safely. • An applicant under these regulations shall apply for the initial issue of a foreign RPA approval at least 90 days before the date of commencement of the proposed operation. • Once authorization has been granted by the authority, the operator: 1. Shall file a flight plan prior to operation of a RPA; 2. Shall follow the operational rules for RPA in Nig.CARs Part 8 : 8.8.1.33 (http://www.ncaa.gov.ng/media/1270/aviation-part-8a.pdf); 3. Shall notify the authority and ATC immediately in the event of a flight cancellation; and 4. Shall, in the case of changes to the proposed flight, submit such changes to the authority for consideration.
Panama	No specific regulations are currently known.
Papua New Guinea	Papua New Guinea currently uses regulations established by the Civil Aviation Authority (CAA) of New Zealand. • Weight - The rules below apply to UAVs under 25 kg. If the aircraft is over 25 kg, another set of rules applies. Contact the CAA for more info. • Approved UAVs - "A person shall not operate a radio controlled model aircraft with a gross mass of between 15 kg and 25 kg unless the aircraft is constructed and operated under the authority of a model aircraft association approved by the director. At present, the only such approved association is Model Flying New Zealand. • Line of Site - Operator needs to be able to see the aircraft with their own eyes (e.g., not through binoculars, a monitor, or smartphone). • Altitude - 120 m (400 ft) max altitude. • Aerodrome - Cannot fly within 4 km of an aerodrome (or in controlled airspace). • Night - Cannot fly at night time. Special permits can be gained by contacting the CAA. • Photography/Video - The Civil Aviation Rules do not cover photography, but many people are concerned about their privacy if they see a drone flying. • Further Rules - Flying RPAS up to 25 kg, and that includes many model aircraft, comes under Part 101, which, among other things, requires operators to fly in a safe manner so their aircraft doesn't create a hazard to other aircraft, persons and property. Pending Rules (Effective August 1, 2015) • Operators of remotely piloted aircraft systems will not be required to seek CAA approval before operating, as long as they remain strictly within the operating limits in Part 101. • All unmanned aircraft operations that exceed the limits in Part 101 will be required to be conducted under the authority of a certificate issued under Part 102. (Only applies to UAVs that are over 25 kg.) The purpose of Part 102 is to enable the director to determine whether to grant an unmanned aircraft operator certificate to a person.

Country	Current laws and regulations for the use of UAVs in pepfar countries
Rwanda	As of March 2016, UAS-specific regulations are in place applying to individuals conducting unmanned aircraft operations within Rwanda airspace with a maximum takeoff weight of 25 kg and flown only within the visual line of sight of the pilot for the following activities: • Aerial photography/filming; • Agricultural crop monitoring/inspection; • Search and rescue or delivery of emergency supplies; • Research and development; • Educational/academic uses; and • Recreational/leisure. 1. All UAS must be registered. 2. A remotely piloted aircraft is eligible for registration if it is owned by the government of Rwanda or one of its institutions; a Rwandan or any other person legally residing in Rwanda; or bodies incorporated under the Rwandan laws. The permit may be obtained by submitting the application form, evidence of ownership (sale receipt or similar), and a registration fee of Rwf 110,000. 3. The registration number must be displayed prominently on the UAS. 4. Local authorities must be notified before launch and flight of the UAS, and consent from property owners must be sought if launch and landing is to take place on that property. 5. Night operations are not permitted under these regulations. 6. The operator must maintain visual line of sight to be able to a) maintain operational control of the remotely piloted aircraft; b) know the remotely piloted aircraft's location; c) determine the remotely piloted aircraft's attitude, altitude and direction; d) observe the airspace for other air traffic or hazards; and e) determine that the remotely piloted aircraft does not endanger the life or property of another. 7. A person may only pilot one UAS at a time. 8. The pilot must avoid other aircraft and yield right of way to all aircraft and vehicles. 9. UAS may not be operated over people or crowds and may not be operated in controlled airspace unless prior authorization by air traffic control has been granted. 10. Operators must have a remotely piloted aircraft system operator certificate (ROC) in accordance with specifications laid out in the regulations. 11. Operators must have a remote pilot license (eligibility requirements are laid out under (31)). 12. Use of autonomous aircraft is strictly limited to public (governmental) functions such as delivery of disaster or emergency supplies, search and rescue, and other government operational missions. 13. Failure to comply with these regulations is liable to a fine not exceeding 20 million (20,000,000) Rwandan francs, and licenses may be revoked.

Country	Current laws and regulations for the use of UAVs in pepfar countries
South Africa	New rules on RPAS were implemented on July 1, 2015. • All operators must hold a CAA-approved license before they can fly. • Flight is not permitted within 50 m of crowds, structures, buildings or individuals without CAA approval. • UAVs must cede to manned aircraft, and operators must tune into air traffic control services for the controlled air space they are flying in. • Flying above or close to a nuclear power plant, prison, police station, crime scene, court of law, national key point or strategic installation will be illegal. • Drones may not be operated under weather conditions that may obstruct the operator's view of the craft. • According to South African Model Aircraft Association's (SAMAA's) rules: - A UAV is an aircraft used for commercial or military purposes. - Model aircraft flight is considered to be commercial if the aircraft is used for any purpose other than the sport of flying, or learning or teaching the sport of flying. - It is commercial if it is used for financial gain, e.g., aerial photography. - The operation of UAVs is excluded from the SAMAA brief, as they are not considered recreational model aircraft. - UAVs are subject to specific sections of the SACAA regulations. • Thus, the CAA defers to SAMAA, and SAMAA defers to the CAA.
South Sudan	No specific regulations are currently known.
St. Lucia	No specific regulations are currently known.
St. Kitts and Nevis	Member of Organization of Eastern Caribbean States. Regulations determined by Eastern Caribbean Civil Aviation Authority. The ECCAA is not known to have established regulations on the usage of civilian drones at this time.
St. Vincent	No specific regulations are currently known.
Suriname	No specific regulations are currently known.
Swaziland	No specific regulations are currently known.
Tajikistan	The Air Code of the Republic of Tajikistan, adopted by the Law of the Republic of Tajikistan on November 13, 1998, will be updated with the following changes to include unmanned vehicles: • The amendments state: - The differentiation between manned and unmanned aircraft - All flights of unmanned aircraft need to be approved by the government • Permissions need to be obtained from the government prior to the operation of unmanned aerial vehicles.
Tanzania	No specific regulations are currently known.
Thailand	As of May 2015, the Thai government had not enacted a regulatory regime governing the use of drones. According to press accounts, new regulations were to be implemented in March 2015 that would divide drone use into two categories: sport and research purposes, and personal use. Drones used under the first category would need to secure prior permission and have a pre-arranged flight path. Drones flown under the second category would not be allowed to be fitted with cameras, unless they were to be used by the media or the film industry. However, as of June 2015, we were unable to find evidence that such laws had been passed.
Trinidad and Tobago	The TTCAA urges all UAS/drone owners to register all drones of weight 750 g or heavier. The public is asked to observe the following: • Drones should not be operated in any open air function or mass public gathering. • Drones should not be flown at a height greater than 121 m or 400 ft above the ground. • Drones should not be operated in a manner that may endanger persons or property. • Drones should not be operated within 5 km from any manned aircraft operations including the boundary of the Piarco International Airport.

Country	Current laws and regulations for the use of UAVs in pepfar countries
Turkmenisatan	No specific regulations are currently known.
Uganda	• Uganda Police in the past announced a ban on importation of aerial camera drones due to security concerns and the absence of regulation in the country. • Those that had aerial drone cameras before the announcement were asked to register with Uganda Revenue Authority. • Reportedly, some have experienced difficulties obtaining permission to fly drones for agricultural and development research purposes in Uganda.
Ukraine	No specific regulations are currently known. The operation of UAVs mostly fall under standard aircraft rules. According to the Air Code of Ukraine, all UAVs weighting less than 20 kg that are used for recreational purposes only are to be registered in the Ukrainian State Registry of Civil Aircrafts. The UAVs that do not fall under these registration criteria have to be declared to local UAV federations (Ukrainian NGOs). For each flight, it is necessary to book air space at the State Enterprise Ukraeroruh. Additional permits are required to use drones for aerial photography (permit from State Avia Service approved by the Ministry of Defense). According to Ukrainian legislation, UAVs that fulfill at least one of these criteria are considered to be dual-purpose equipment: • Capacity to perform controlled autonomous flight and navigation. • Capacity to perform flights controlled by an operator but outside of his/her direct eyesight. • Remote control equipment to the above-mentioned types of UAV is also treated as dual-purpose. • While import of UAVs and spare parts is not subject to any additional procedures related to dual-purpose classification, export of dual-purpose equipment is subject to additional customs procedures by State Export Control.
Uzbekistan	Uzbekistan has banned the import, sale, and usage of drones, citing "safety and security concerns." The ban began on January 1, 2015.
Vietnam	• The 2008 decree on management of unmanned aircraft and ultralight aircraft gives authority over the flight of unmanned aircraft to the Ministry of Defense. • These duties include the organization of aviation clubs, establishing airfields and flight zones, and managing and supervising the flight of unmanned vehicles. • The flight of UAVs is not legal without a license from the Operations Bureau of the General Command Post, and applications for licenses must be received at least 14 days in advance of the proposed flight. Licenses will be issued within 10 days of submission of the application. One license can be valid for multiple flying events, as long as users list places they plan to fly their drones in their application. • Filming or taking photographs in the air using a UAV is not permitted without a license. • Penalties for violation are not specified in the 2008 decree but there have been incidents where foreigners were deported upon violating rules, and drones with cameras have been confiscated upon flying in restricted areas.
Zambia	No specific regulations are currently known.
Zimbabwe	• Operations of all UAVs in Zimbabwe shall be conducted only after registration and getting the requisite approval from the authority. • Owners and/or those in the possession of UAVs/Unpiloted Aircraft Systems are directed to: - Register the UAVs/Unpiloted Aircraft Systems with the Civil Aviation Authority of Zimbabwe, General Manager's office, Level 3, Harare International Airport, Harare or Private Bag 7716, Causeway, Harare. - For the purposes of registration, the applicants shall submit specifications documentation for their UAVs from the manufacturers and a copy of the ZIMRA Bill of Entry into Zimbabwe.

III. KEY CASE STUDIES

A. CASE STUDY 1: MSF USING MULTI-COPTER DRONE TO TRANSPORT TUBERCULOSIS SPUTUM SAMPLES IN PAPUA NEW GUINEA[23]

KEY FACTS

Country	Papua New Guinea
Environment	Last mile, limited infrastructure, swampy, impassable terrain
Key actors	MSF, Matternet
UAV technology	Multi-rotor
Payload	1 kg (now up to 2 kg possible)
Date of operation	September 2014
Distances	Up to 20 km
Frequency	Unknown
Goal of project	Speed up tuberculosis testing

OVERVIEW

Limited access to health care diagnostics due to severe logistical constraints in Papua New Guinea (PNG) led Médecins Sans Frontières (MSF) to be one of the first humanitarian organizations to test the use of delivery drones, in this case, to transport sputum samples for tuberculosis testing. In 2014, technological challenges restricted the field use of this technology, but important lessons concerning acceptability and proof of concept are setting the stage for improvements in future missions.

MSF considered this pilot project to be just a trial of the technology, and did not carry out a comparative analysis of costs to determine whether payload delivery by drone would be less costly than by car. That said, MSF notes that the question of effectiveness goes beyond cost, and includes consideration of the time it takes to deliver the payload and the potential risk of not being able to access certain health clinics by road due to heavy rains. In this sense, the benefits that could be derived from using drones were most clearly visible in terms of delivery time (55 minutes versus 4 hours by car) and being able to avoid the risk of taking a car journey through difficult-to-access areas. Many additional details of this deployment, such as numbers of flights, are subject to a non-disclosure agreement between MSF and Matternet.

LESSONS LEARNED

For MSF, the pilot project revealed that the low range (20 km of Matternet's drone) was a notable constraint. Since the minimum distance needed to be covered was 43 km, MSF considered the need to swap batteries midway to be a significant disadvantage. In addition, a couple of UAVs crashed in the forest and samples were lost. At the time, the Matternet platform was still under development and thus not yet as mature as the Matternet One or Matternet Two versions. Though the constraint of 20 km was known before the project, MSF still decided to proceed with the pilot as a learning opportunity and initial feasibility study. In conclusion, MSF believes that "the pilot project was worth it, but it needs further development to achieve reliable and regular operations."[24]

In particular, MSF was able to clarify minimum requirements for future uses of UAVs for this purpose. These include:[25]

- Control: UAVs need to be easy to control, ideally with standard technology such as tablets and smart phones by MSF staff.
- Maintenance: Should be low and parts should be easily replaced or repaired even in remote environments.
- Range and Maneuverability: Hybrid UAVs were seen as providing both the range and maneuverability that is required in MSF's operations.

[23] FSD. *Using drones for medical payload in Papua New Guinea.* http://drones.fsd.ch/en/using-drones-for-medical-payload-delivery-in-papua-new-guinea-case-study/ (accessed November 4, 2016).

[24] FSD. *Using drones for medical payload in Papua New Guinea.* http://drones.fsd.ch/en/using-drones-for-medical-payload-delivery-in-papua-new-guinea-case-study/ (accessed November 4, 2016).

[25] Personal correspondences between Denise Soesilo and MSF staff from June 21, 2016–July 14, 2016.

NEXT STEPS

MSF continues to explore drone solutions to support its distribution efforts in PNG and beyond. While specific interests remain confidential, it is known that MSF is looking for a solution that will not require battery swapping. Such a requirement will most likely mean a hybrid drone that can fly long distances. MSF was looking to carry out a second test either with Matternet or other companies in 2017, but it has also not made public where in PNG this will happen.

Since the trial in PNG, Matternet has further developed its technology and launched the Matternet One and the Matternet Two. These Matternet drones carry an integrated box with a volume of around 3 liters that is securely protected by the UAV.

B. CASE STUDY 2: UAV TRANSPORTATION OF BLOOD AND STOOL SAMPLES IN MADAGASCAR[26]

KEY FACTS

Country	Madagascar
Environment	Last mile, limited infrastructure
Key actors	Vayu, Stony Brook University, Government of Madagascar, USAID
UAV technology	Hybrid
Payload	2.2 kg
Date of operation	July 2016
Distances	60 km
Frequency	Unknown
Goal of project	Speed up transportation of blood and stool samples

OVERVIEW

Vayu, Inc. and Stony Brook University, with support from the Madagascar government and backing from the U.S. Agency for International Development (USAID), completed the first-ever series of long-range, fully autonomous drone flights with blood and stool samples in July 2016 in Madagascar. The samples were transported from rural villages in the Infanadiana district of Madagascar to Stony Brook's Center ValBio research station, on the edge of Madagascar's Ranomafana National Park, where the samples could be properly stored and analyzed.

Project partner Vayu made the GPS-guided hybrid UAVs used in the project. The UAVs take off and land vertically, like a helicopter, but switch to faster and more efficient fixed-wing flight once they reach altitude.

"The flights to and from villages in the Ifanadiana district ushers in a new era in bringing health care to people living in really remote settings. This would not have been possible without the support of the government and people of Madagascar," said Dr. Peter Small, the founding director of Stony Brook's Global Health Institute. "In this context, drones will find innumerable uses such as accelerating the diagnosis of tuberculosis and ensuring the delivery of vaccines."[27]

The Vayu drone can carry a payload of 2.2 kg, or 160 lab samples or four life-saving blood units. It can fly more than 60 km on a single battery charge and is operated through a smart phone application.

Faculty and students from Stony Brook University Medical Center found the UAV startup company Vayu when they sought out innovative solutions to speed up the diagnosis services and the transportation of blood and stool samples. Vayu was founded specifically to develop medical delivery drones as a way to transport blood, stool, and tissue samples faster and improve diagnostics services.

"Vayu's accomplishment is as significant for the field of public health in developing countries, where limited access hinders health care, as it is for the future of autonomous unmanned vehicles," said Vayu's CEO, Daniel Pepper, a former international journalist and medical student.[28]

[26] New Atlas. *Drones take samples to the sky in Madagascar.* http://newatlas.com/drones-samples-madagascar/44799/ (accessed November 7, 2016).

[27] Stony Brook University. *Drones used to improve healthcare delivery in Madagascar.* http://sb.cc.stonybrook.edu/news/general/2016_08_05_DronesInMadagascar.php (accessed November 6, 2016).

[28] Stony Brook University. *Drones used to improve healthcare delivery in Madagascar.* http://sb.cc.stonybrook.edu/news/general/2016_08_05_DronesInMadagascar.php (accessed November 6, 2016).

LESSONS LEARNED

The benefits of hybrid drones seem promising, but as of yet, few cases are available to draw conclusions. Little public information is available from this case study.

NEXT STEPS

Stony Brook investigators, in partnership with the National TB Program and the Institute Pasteur of Madagascar, have been awarded a TB REACH grant to implement a drone-based TB program (DrOTS) that is expected to begin in remote southern Madagascar in the spring of 2017..

C. CASE STUDY 3: USING DRONES TO TRANSPORT DRIED BLOOD SPOT SAMPLES WITH COMPARATIVE COST ANALYSIS IN MALAWI

KEY FACTS

Country	Malawi
Environment	Last mile, limited infrastructure
Key actors	UNICEF, Malawi Ministry of Health, Matternet
UAV technology	Multi-rotor
Payload	1 kg (now 2 kg)
Date of operation	March 2016
Distances	Up to 20 km per battery (1.5-10 km tested in Malawi)
Frequency	Total of 93 flights during test period
Goal of project	Assess feasibility of transporting laboratory samples for early infant diagnosis of HIV

OVERVIEW

In spring 2016, UNICEF, in partnership with Matternet and the government of Malawi, tested drones for the transport of dried blood spot (DBS) samples in Malawi. The goal of the trial was to find a more cost-effective way to reduce waiting times for HIV testing of infants compared to motorbike transport. This trial was supported by Matternet, and used simulated samples to successfully complete 10-km test flights from a community health center to the Kamuzu Central Hospital laboratory. The test flights assessed the concept's viability, including cost and safety.

UAVs have been previously used for surveillance and assessments of disasters, but this was the first known use of UAVs on the continent for improvement of HIV services. "HIV is still a barrier to development in Malawi, and every year around 10,000 children die of HIV," said Mahimbo Mdoe, UNICEF representative in Malawi. "This innovation could be the breakthrough in overcoming transport challenges and associated delays experienced by health workers in remote areas of Malawi."[29]

"In 2014, nearly 40,000 children were born to HIV-positive mothers in Malawi. Quality care for these children depends on early diagnosis, which requires taking dried blood samples from the health center to the central laboratory for testing. We hope that UAVs can be part of the solution to reduce transportation time and ensure that children who need it start their treatment early," said Mdoe.[30]

In 2014, around 10,000 children in Malawi died from HIV-related diseases, and less than half of all children who needed treatment were on it. Currently, it takes an average of 11 days to get samples from health centers to a testing lab, and it can take as long as eight weeks for the results to be delivered back; sometimes samples get lost on the way. Samples are currently transported between the health centers and the lab by road, either by motorbike or local authority ambulances. Several factors — including the high cost of diesel fuel, poor infrastructure conditions, and limited distribution schedules — have resulted in extreme delays in lab sample transport, constituting a significant impediment for the scaling up of pediatric ART effectiveness.[31] The longer the delay between the test and the results, the longer the patient has to wait for treatment, increasing the chance of complete loss to follow-up and the worsening of the child's health status.

29 UNICEF. *Malawi tests first unmanned aerial vehicle flights for HIV early infant diagnosis*. http://www.unicef.org/media/media_90462.html (accessed November 7, 2016).

30 Ibid.

31 UNICEF. *Malawi tests first unmanned aerial vehicle flights for HIV early infant diagnosis*. http://www.unicef.org/media/media_90462.html (accessed November 7, 2016).

"Malawi has pioneered a number of innovations in the delivery of HIV services including the Option B+ policy, which puts mothers on a simple, lifelong treatment regime," said Malawi Minister of Health Dr. Peter Kumpalume. "We have also pioneered the delivery of results from the central laboratory to the health facilities through text messages. We believe our partnering with UNICEF to test UAVs is another innovation and will help in our drive to achieve the country's goals in HIV prevention and treatment."[32]

LESSONS LEARNED

VillageReach, which was in charge of the comparative cost analysis, found that in most cases, motorbikes presented a cheaper option.[33] At the same time, they stated that "Because these 'drones' have never been deployed to transport health commodities at scale, we cannot know the exact costs yet, but we know enough to make very good guesses (…) the same is true for many of the motorcycle costs."[34] In the same report, they stated that "...likely the optimal system for transporting DBS and lab results will not be composed only of UAV or only of motorcycles; it will take advantage of the strengths of both technologies to minimize both costs and transport time. This initial cost study is a key first step in responsible, informed decision-making about implementation of this potentially life-saving technology."

Permission to carry out the UAV cargo trials was applied for with local authorities for the trial period and was quite a time-consuming process as they were to be the first UAV trials in Malawi. New permission will be needed if Matternet will continue its operations in Malawi. It should then be a smoother process, estimated to a couple of months at the most.[35]

32 Ibid.

33 Personal correspondence between Denise Soesilo and UNICEF Staff. October 6, 2016.

34 VillageReach. *Looking to the sky for answers: Understanding the cost of UAVs at the last mile*. http://www.villagereach.org/2016/03/28/looking-to-the-sky-for-answers-understanding-the-cost-of-uavs-at-the-last-mile/ (accessed November 5, 2016).

35 Personal correspondence between Helena Samsioe and Matternet Staff. September 28, 2016.

NEXT STEPS

UNICEF Malawi is currently evaluating the Phase One trial, and if favorable, the second phase will carry out test flights from remote areas of the country. We have not been able to obtain any additional information to update this report.

D. CASE STUDY 4: DELIVERING TRANSFUSION BLOOD AND OTHER MEDICAL ITEMS ACROSS RWANDA

KEY FACTS

Country	Rwanda
Environment	Last mile, limited infrastructure, mountainous
Key actors	Rwanda Ministry of Health, Rwanda Ministry of ICT, Zipline
UAV technology	Fixed-wing, parachute drops
Payload	1.5 kg
Date of operation	October 2016-present
Distances	150 km round trip
Frequency	15 deliveries per day
Goal of project	Speed up access to essential blood products

OVERVIEW

The government of Rwanda has commissioned Zipline to do the first commercial operation of cargo drones in the world. The eventual aim is to handle all blood deliveries to 21 transfusion facilities and to put 11 million citizens within a 30-minute delivery zone of essential medical products. To date, Zipline has 15 drones at its distribution center in Muhanga. Each drone makes an average of one trip per hour, 15 to 45 minutes to a health facility, so an average of 30 minutes each way. The distribution with 15 drones makes 15 shipments/hour or 150 shipments per a 10-hour day.

There are few blood collection and distribution centers in Rwanda; those that exist are mostly located around referral hospitals in major cities. Most health facilities are not adequately equipped to store medical products that require careful handling, transport, and storage. Replenishing blood supplies is done about twice a week.

Transportation to health facilities can take up to five hours by car or motorbike, and this process often requires staff such as lab technicians to leave their work stations to follow up on the order and delivery.

Given the difficulties in predicting the kind of conditions a health facility may encounter, blood and some drugs may not be supplied or are only supplied in small quantities in the usual supply chain system, but can still be needed in an emergency situation. The fact that it takes up to five hours for blood and emergency drugs to be delivered or have a patient transferred to another facility usually increases the risk of preventable death or incurable conditions in the process.

The Zipline cargo drones are operated out of operation centers the size of a shipping container that are placed close to the public medical warehouses. Each operation center has a service radius of up to 75 km. The drones, called "Zips," can carry at most 1.5 kg of cargo, which the UAV drops into a marked "mailbox" area using a parachute before it returns without landing to the operation center. The UAVs are able to land on the equivalent space of two parking spaces and are launched with a catapult. Each drone is estimated to make about 15 deliveries per day.

Zipline drones use a GPS technology, RTK GPS, which allows them to precisely target the drop point and land in a small space. Ten to 20 UAVs can fly simultaneously, with operators and software tracking each UAV and the inventory it is carrying. The UAVs are also "aware" of each other's position and routing in-flight. The delivery system relies on Rwanda's well-expanded cellular network (3G and 4G) as orders are placed by text message to the distribution center. Within five minutes, the order can be loaded and sent. It takes about 30 minutes to reach the farthest health facility.

The drones' delivery system costs less than it would cost to make the same delivery using a motorbike, which was previously the only convenient means for an emergency supply run. Drones offer a faster and safer delivery considering the Rwandan landscape of high mountains and difficult terrain.

Zipline works directly with the Ministry of Health and the Ministry of ICT; its system is integrated into Rwanda's supply chain system. The distribution center and drone-port is located in Muhanga District of the Southern Province, co-located with a medical warehouse to maximize speed and product availability. Zipline serves 21 health facilities in western Rwanda, with an aim to build two more distribution centers and drone-ports in other parts of the country to cover the whole nation. The system at the distribution center requires a constant supply of electricity, Internet connectivity, and cellular connectivity. It includes a back-up power system that can keep it running without interruption for up to 24 hours, and could operate via a generator or solar power if longer energy gaps are expected.

Staff on-site is made up of engineers, flight operators, and operations and supply chain specialists. Zipline plans to hire and train local recruits for continuing operations, with numbers yet to be determined and plans to be further developed. The distribution center can operate 24/7. In addition, Zipline collaborates closely with the Civil Aviation Authority to understand and create flight paths that avoid all sensitive locations like defense/security landmarks and airports.

UAVs can deliver medicines and medical supplies forgoing the following costs: driver and health worker time and wages, vehicles, fuel, storing RBC on site at health facilities (utility, equipment, value of inventory), blood units that go to waste when they expire (including $100/unit to test and type the blood), and most importantly, averting patient death due to delays in blood delivery. Deliveries to health facilities typically take more than five hours, depending on the location of the health facility. The current system has a very low reliability, during the rainy season especially; roads can become impassable, preventing trucks, vans, and even motorbikes from successfully completing their deliveries.

Zipline established long-term (2+ year) service contracts with the Ministry of Health wherein they charge per delivery, with a minimum number of guaranteed deliveries per month. Price per delivery varies based on the volume of deliveries and delivery context but is generally on par with status quo delivery costs.[36]

Also in Rwanda, Redline Foundation (led by Jonathan Ledgard) and architect Norman Foster are planning a UAV drone-port initiative to build the world's smallest airports for drones to facilitate UAV logistics and shipments. The lobbying for this project may well have acted as an enabling factor for Zipline as the government was already well acquainted with UAVs through conversations with Redline.

LESSONS LEARNED

One of the reasons operations were able to commence smoothly in collaboration with all the necessary authorities and permits is because over the past several years, the government of Rwanda has collaborated closely on the drone-port initiative. Local authorities and ministries had grown accustomed to the possibility of using UAVs for a long time, clearing the path for an enabling regulatory environment.

The parachute system is unique and provides significant advantages over systems that land to deliver cargo. The drones do not touch down at health facilities; no energy infrastructure, landing/launching equipment, battery charging stations, or staff with knowledge of how to operate the Zips and swap batteries are needed at the remote health facilities. Thus, minimal infrastructure and training are needed at the receiving locations. The health centers only need the ability to send an SMS for on-demand delivery.

NEXT STEPS

Field tests carried out in September and October proved to be successful and the system was officially launched in mid-October. It started with transfusion blood, but is set to expand in the near future to include emergency drug supplies, oxygen, samples for lab tests, vaccines, and other cold chain items. Zipline has secured a considerable amount of venture capital funding, making it the most well-funded cargo drone company at present.[37]

E. CASE STUDY 5: UAVS IN OUT-OF-HOSPITAL CARDIAC ARREST IN STOCKHOLM COUNTY, SWEDEN[38]

KEY FACTS

Country	Sweden
Environment	Urban and rural
Key actors	Karolinska Institute, KTH Royal Institute of Technology
UAV technology	Multi-rotor
Payload	1.4 kg
Date of operation	June 2014 and October 2016
Distances	10 km
Frequency	N/A
Goal of project	Decrease emergency response time and delivery of AEDs

OVERVIEW

The Karolinska Institute in Stockholm, Sweden, together with partners, has tested UAVs' ability to decrease response time and to deliver automated external defibrillators (AEDs) to out-of-hospital cardiac arrests (OHCAs). In Sweden, the use of drones by civilians is restricted; they cannot be operated beyond a pilot's range of sight. Test flights within the pilot's range of sight were therefore carried out in rural areas calculated with data based on historical OHCAs in the archipelago surrounding Stockholm County.

Two different multi-rotor UAVs from the German company, HEIGHT TECH GmbH & Co. KG, were used. These were operated by two licensed UAV pilots and flown in manual flight command mode. The UAVs had a maximum velocity capacity of 70 km/h, with a maximal range of 10 km.

36 Republic of Rwanda: Ministry of Youth & ICT. *Rwanda signs agreement with Zipline to use drones for delivery of essential medical products.* http://www.myict.gov.rw/press-room/latest-news/latest-news/?tx_ttnews%5Btt_news%5D=441&cHash=5f6e73ee587c8f80e8cf769f8c096b9b (accessed November 6, 2016).

37 FSD. *Cargo drones in Humanitarian Action: Meeting Summary.* http://drones.fsd.ch/en/cargo-drones-in-humanitarian-contexts-meeting-summary/ (accessed November 6, 2016).

38 Claesson et al. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* (2016) 24:124.

GPS coordinates from historical OHCAs in Stockholm County were used in a model using a Geographic Information System (GIS) to find suitable placements and visualize response times for the use of an AED-equipped drone. Two different geographical models, urban and rural, were calculated using a multi-criteria evaluation (MCE) model. Test flights with an AED were performed to these locations in rural areas.

In total, based on 3,165 retrospective OHCAs in Stockholm County between 2006–2013, 20 locations were identified for the potential placement of a drone. In a GIS-simulated model of urban OHCA, the drone arrived before Emergency Medical Service (EMS) in 32 percent of cases, and the mean amount of time saved was 1.5 minutes. In rural OHCAs, the drone arrived before EMS in 93 percent of cases, with a mean amount of time saved of 19 minutes. In test flights to these rural locations, latch-release of the AED from a low altitude (3-4 m) or landing the drone on flat ground was the safest way to deliver an AED and was superior to a parachute release.

LESSONS LEARNED

The difference in response time for EMS between urban and rural areas is substantial, as is the possible amount of time saved using this UAV system. Use of drones in rural areas to deliver an AED in OHCAs may be safe and feasible. Suitable placement of drone systems can be designed by using GIS models. However, the UAV system needs to fit into the health supply chain, and little is known regarding how productive the system might be in clinical reality. The system remains theoretical.

NEXT STEPS

The first round of flights was carried out in June 2014, and the research study was published in October 2016. A second round of flights and research study commenced in October 2016. Considering there are other known projects using UAVs to respond to cardiac arrests, it seems likely that the idea will develop at least to the testing stage. However, recent UAV regulation updates in Sweden as of October 2016 require permission for all UAV users and will most likely only be granted to actors in the field of emergency response or the like.

F. CASE STUDY 6: UAVS IN COMMUNITY EMERGENCY RESPONSE TEAMS IN THE MALDIVES[39]

KEY FACTS

Country	Maldives
Environment	Last mile, limited infrastructure, island territory
Key actors	UNDP, DJI, Government of the Maldives
UAV technology	Multi-rotor
Payload	1-6 kg (depending on UAV model)
Date of operation	November 2016
Distances	Up to 5 km (primary use: photography and filming)
Frequency	N/A
Goal of project	Assist emergency response teams in determining issues in the health supply chain

OVERVIEW

Composed of nearly 1,200 islands and 26 atolls, the Maldives faces dangers of sudden intense storms, rapid climate change, and rising sea levels as well as an infrastructure challenge for emergency response teams. DJI, UNDP (United Nations Development Program), and the government of the Maldives are exploring ways for UAVs to enhance the work of community emergency response teams. Though these are not strictly cargo drones, the ability to quickly assess damage to supply chains in the aftermath of disasters will prove incredibly useful.

UAVs have been seen previously in the Maldives, but until now they have not been put to work systematically to enable disaster responders to survey damage and guide and assist emergency response teams. A key part of emergency response is quickly assessing the best logistical routes to provide aid and assessing the damage to the existing health supply chain. This is where the DJI drones, which will be primarily used for mapping and filming, come in. They will enable real-time

[39] Personal correspondence between Helena Samsioe and Caroline Briggert (DJI), October 24, 2016.

monitoring during disasters such as flooding. They will serve as an information tool for search and rescue teams as well as providing information on infrastructure damage to guide public health supply chain priorities and ground transportation.

DJI is not focusing on cargo drones even though its drones have the potential to carry lighter cargo over shorter distances. However, focusing on photography and filming can be of great value to health supply chains and humanitarian operations.

LESSONS LEARNED

Not yet known; full implementation was scheduled to take place in November 2016.

NEXT STEPS

Not yet known. However, DJI recently put a greater focus on serving the humanitarian community by launching the DJI Global Citizenship Program in October 2016 with a focus on further serving projects in the environment, health, and educational sectors.

IV. CONCLUSION

Pilot testing of cargo UAVs in the health supply chain has been limited to a handful of examples. From this and past investigations, it is evident that many trials are very basic, and recommendations have to be based on limited field experiences. In addition, non-disclosure agreements are often signed between partnering groups, so much useful data such as numbers of flights, staff and costs involved, and other information cannot be made available to the public. This may slow down the diffusion of information for further learning.

Nonetheless, the case studies above provide some information on experiences from UAV projects in the humanitarian supply chain to date. It is also important to note that the sector is in the embryonic stage of its development, with only Zipline providing a scaled operation at this point. However, various projects are planning several field tests, and more information should become available within the next months and years. Due to enabling regulatory environments in many lower- and middle-income countries (LMICs), the potential for further development and scale-up of operations using cargo UAVs is great. Europe and the United States, in contrast, have repeatedly shown themselves to be nervous about the security concerns of commercializing UAVs on a mass scale. Recently, the United States opened the way for Zipline to conduct UAV transportation of medical supplies to rural communities in Maryland and Nevada. It will be interesting to follow this; perhaps a successful trial will result in less restrictive UAV regulations in the United States.

Below is a summary of the pros and cons of UAVs in the humanitarian sector.

A. SWOT ANALYSIS OF UAVS IN THE HUMANITARIAN SUPPLY CHAIN

Strengths	Weaknesses
• Faster transportation of emergency medical supplies and diagnostic services • Increased access to essential medicine, diagnostics, and treatment • Contribution to a more responsive and flexible transport infrastructure	• Limited distance • Limited payload • Reliability issues, as many models are prototypes
Opportunities	**Threats**
• Additional applications: mapping, data collection, search and rescue, real-time surveillance • Increased quality of health service delivery • Reduced cost of public health service delivery	• Restrictive/unclear regulatory frameworks • Security concerns • Criticism for testing new technology in vulnerable communities • Risk of poor community acceptance

Figure 3: SWOT analysis of UAVs in the humanitarian supply chain

B. HEALTH ECONOMIC ANALYSIS

The economics of UAVs in health supply chains needs further research before a comprehensive economic analysis can be made, but the information available indicates the potential to push down the cost of UAV delivery to equal or less than current distribution systems with cars and motorcycles once operations run at a larger scale. However, this depends on how the calculation is made. Comparing UAV cost to motorcycle cost strictly will, in most cases, speak in favor of using a motorcycle. However, calculating the cost of fuel as well as the human resource capacity required to operate a vehicle or motorcycle for hours compared to a shorter UAV flight — with a single person operating multiple drones — paints a different picture.

There are also big differences in the human resources costs within different UAV systems. A fixed wing craft such as that used by Zipline which does not land has limited training costs because trained staff are only needed at the "nest," whereas a UAV that lands has much higher training costs because all facility staff will need to understand care and operation of the drone. The risk of theft or damage would go up with landing as well. Unfortunately, it is extremely difficult to assess these costs, as the data remain confidential within projects.

Few UAV health economic analyses are available, but HERMES Logistics Modeling team (HERMES) and VillageReach have assessed the unmanned aerial system costs necessary for a UAS to be favorable over a traditional multi-tiered land transport system for vaccines. The results show that implementing the UAS improves vaccine availability (96 percent versus 94 percent) and produces logistics cost savings of 8 cents per dose administered when compared to the land transportation system.[40] The UAS maintained cost savings in all vaccination analyses made, ranging from 5 cents to 21 cents per dose administered.[41]

The minimum UAV volumes necessary to achieve cost savings were substantially smaller (up to 0.40 liter) than the currently assumed UAV payload of 1.5 liters. The results also showed that the maximum UAS costs that could achieve savings over the traditional multi-tiered land transport system (TMLTS) were greater than the currently assumed costs under realistic flight conditions. HERMES and VillageReach conclude that implementing a UAS could increase vaccine availability and decrease costs in a wide range of settings and circumstances, if the drones are used frequently enough to overcome the capital costs of installing and maintaining the system. Hermes and partners find that the major drivers of costs savings from using UAS are road speed of traditional land vehicles, the number of people needing to be vaccinated, and the distance that needs to be traveled.[42]

Looking at the conclusions from HERMES and VillageReach and the predictions of the Zipline UAS in Rwanda by the Rwandan government, most likely UAVs will be favorable to land transport systems from a health economic perspective when the cargo is small, light, valuable, and time-sensitive, especially when the routes do not change and most of the process can be automated.

Cost per UAV flight for the Ghana UAV trials conducted by Drones for Development were reported to be $15 for a 30-minute flight. UAV trials conducted by Matternet of up to 2 kg of cargo and for a 10-km route have been estimated at 24 cents per flight.[43] However, little detail and information is known about the costs per UAV flight (and will of course vary depending on cargo, distance, and weather conditions) because such information is sensitive in a competitive UAV environment, which makes it difficult to compare.

According to shipping industry analysts, Amazon typically pays between about $2 and $8 to ship a package, with the cheapest option through the postal service and the most expensive via UPS or FedEx.[44] Amazon is looking to decrease logistic costs with its upcoming UAV delivery network and to get a maximum number of deliveries and efficiencies out of the UAV delivery network. Sometimes the customers will be willing to pay more for expedited delivery, which UAV delivery can offer. After all, the shortest path between two points is as the drone flies.

As concluded by VillageReach in its cost analysis for the Malawi UAV trial with UNICEF and Matternet, "Modeling costs is complex work, and in many ways, as much of an art as it is a science. It requires us to identify and quantify all of the factors that drive the costs of a system. Modeling can provide incredibly valuable input for

[40] Hadari LA et al., *The economic and operational use of drones to transport vaccines. Vaccine* 34 (2016) 4062-4067..

[41] Ibid.

[42] Ibid.

[43] TED talk. *No roads? There's a drone for that.* https://www.ted.com/talks/andreas_raptopoulos_no_roads_there_s_a_drone_for_that/transcript (accessed November 7, 2016).

[44] Robotenomic. *The economics of Amazon's delivery drones.* https://robotenomics.com/2014/06/17/the-economics-of-amazons-delivery-drones/ (accessed November 7, 2016).

decision-makers when evaluating an innovation like UAVs. More than likely, the optimal system for transporting DBS and lab results will not be composed only of UAV or only of motorcycles; it will take advantage of the strengths of both technologies to minimize both costs and transport time. This initial cost study is a key first step in responsible, informed decision-making about implementation of this potentially life-saving technology."[45]

It is also clear from the limited case studies available to date that the local context will be a significant factor in any cost analysis. In Rwanda, the relatively mountainous terrain and lack of significant transportation infrastructure make drones a much more attractive option. Conversely, Zambia, with generally good infrastructure and a relatively flat landscape, would be far less attractive.

The Rwanda Ministry of Youth and ICT seems confident that the UAV delivery system will provide a cheaper option compared to the current distribution system.[46] However, it is recommended that research initiatives follow the ongoing UAV trials and programs globally, so that in the near future we are able to make informed decisions on a larger scale.

C. THE WAY FORWARD: FINAL EVALUATION AND RECOMMENDATIONS

There seem to be significant benefits to using UAVs in health supply chains because their fast delivery potential and increased ability to reach relatively inaccessible areas may help health workers save lives. However, their use remains a new concept and little is known on how to successfully implement them as a sustainable and integrated part of the current system. For UAVs to work as intended and to reach their full potential, they need to be an integrated part of the whole chain, and not simply used on an ad hoc basis.

It is also important to thoroughly analyze when and where UAVs should and should not be used. The optimal system will most likely not comprise only UAVs or ground transport, but instead employ some combination of both systems to take advantage of their respective strengths to minimize both costs and transport time. An additional interesting component moving forward is the environmental aspect. Because the majority of UAVs used in health supply chains run on rechargeable battery power and/or solar power, they can present a more environmentally friendly option compared to road distribution.

In terms of the technology, we have witnessed rapid development in the UAV sector with an increased number of UAV companies starting to target their technology to specific humanitarian missions such as delivery of emergency medical supplies. This development will most likely continue and result in a price drop moving forward. It will also push technological developments to further meet the needs in health supply chain delivery and services, such as being able to fly longer distances with heavier payloads. The recent development of hybrid drones is an interesting step in this direction. However, it seems most likely that the real disruptive shift will occur if and when military UAV technology (with increased payload and range capacity) is adopted in the commercial market, though this will pose new challenges to regulators and already nervous governments.

As for regulations at this point, UAV landscapes differ depending on the region and country. In Europe and the United States, UAV use in health supply chain delivery is greatly limited due to current regulations restricting users from flying UAVs beyond visual line of sight; however, an exception to Zipline was recently granted. On the other hand, many of the countries where humanitarian and aid workers operate currently do not have any framework for UAVs. This creates both opportunities and problems going forward. An interesting exception is Rwanda, where a thorough nationwide legal UAV framework has been adapted allowing for UAVs to fly beyond visual line of sight for the delivery of emergency medical supplies.

[45] VillageReach. *Looking to the sky for answers: Understanding the cost of UAVs at the last mile.* http://www.villagereach.org/2016/03/28/looking-to-the-sky-for-answers-understanding-the-cost-of-uavs-at-the-last-mile/ (accessed November 5, 2016).

[46] Republic of Rwanda: Ministry of Youth & ICT. *Rwanda signs agreement with Zipline to use drones for delivery of essential medical products.* http://www.myict.gov.rw/press-room/latest-news/latest-news/?tx_ttnews%5Btt_news%5D=441&cHash=5f6e73ee587c8f80e8cf769f8c096b9b (accessed November 6, 2016).

The costs of UAVs in health supply chains need further research before a comprehensive health economic analysis can be made, but so far the information available indicates the potential to push down the cost of UAV delivery to equal or even to less than current ground distribution systems.[47] In addition, the use of UAVs in public health supply chains can potentially defray the human cost of delayed emergency medical supplies, diagnosis, and treatments, further strengthening the case for more follow-up on this technology.

Last but not least, local adaptation will be key for UAVs to be successfully and sustainably implemented in health supply chains. Close collaboration with governments, national universities, and training programs in the health and engineering sectors is crucial for local operations, maintenance, development, and future sustainability.

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[47] eHealth News. *Drones could cut vaccine delivery costs.* http://ehealthnews.co.za/drones-vaccine-delivery-costs/ (accessed November 5, 2016).

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PULVER, A., WEI, R., & MANN, C. (2016). "LOCATING AED ENABLED MEDICAL DRONES TO ENHANCE CARDIAC ARREST RESPONSE TIMES." *PREHOSPITAL EMERGENCY CARE*, 20(3), 378-389.

ABSTRACT

Out-of-hospital cardiac arrest (OHCA) is prevalent in the United States. Each year, between 180,000 and 400,000 people die due to cardiac arrest. The automated external defibrillator (AED) has greatly enhanced survival rates for OHCA. However, one of the important components of successful cardiac arrest treatment is emergency medical services (EMS) response time (i.e., the time from EMS "wheels rolling" until arrival at the OHCA scene). Unmanned Aerial Vehicles (UAV) have regularly been used for remote sensing and aerial imagery collection, but there are new opportunities to use drones for medical emergencies. The purpose of this study is to develop a geographic approach to the placement of a network of medical drones, equipped with an automated external defibrillator, designed to minimize travel time to victims of out-of-hospital cardiac arrest. Our goal was to have one drone on scene within one minute for at least 90 percent of demand for AED shock therapy, while minimizing implementation costs. In our study, the current estimated travel times were evaluated in Salt Lake County.

CLOTHIER, R. A., GREER, D. A., GREER, D. G., & MEHTA, A. M. (2015). "RISK PERCEPTION AND THE PUBLIC ACCEPTANCE OF DRONES." *RISK ANALYSIS,* 35(6), 1167-1183.

ABSTRACT

Unmanned aircraft, or drones, are a rapidly emerging sector of the aviation industry. There has been limited substantive research, however, into the public perception and acceptance of drones. This article presents the results from two surveys of the Australian public designed to investigate 1) whether the public perceive drones to be riskier than existing manned aviation, 2) whether the terminology used to describe the technology influences public perception, and 3) what the broader concerns are that may influence public acceptance of the technology. We find that the Australian public currently hold a relatively neutral attitude toward drones. Respondents did not consider the technology to be overly unsafe, risky, beneficial or threatening. Drones are largely viewed as being of comparable risk to that of existing manned aviation. Furthermore, terminology had a minimal effect on the perception of the risks or acceptability of the technology. The neutral response is likely due to a lack of knowledge about the technology, which was also identified as the most prevalent public concern as opposed to the risks associated with its use. Privacy, military use, and misuse (e.g., terrorism) were also significant public concerns. The results suggest that society is yet to form an opinion of drones. As public knowledge increases, the current position is likely to change. Industry communication and media coverage will likely influence the ultimate position adopted by the public, which can be difficult to change once established.

LIPPI, G., & MATTIUZZI, C. (2016). "BIOLOGICAL SAMPLES TRANSPORTATION BY DRONES: READY FOR PRIME TIME?" *ANNALS OF TRANSLATIONAL MEDICINE, 4*(5).

ABSTRACT

According to the concept originally introduced by George D. Lundberg in the 1980s, the total testing process entails three essential and sequential parts: the preanalytical phase, the analytical phase and the postanalytical phase. Briefly, the preanalytical phase encompasses all those (prevalently) manually intensive activities designed for obtaining, handling, transporting, preparing and storing biological samples before testing. Reliable evidence, accumulated after decades of research aimed to improve the total quality of the testing process, underpins the notion that the vast majority of problems in laboratory diagnostics are attributable to incorrect or inappropriate preanalytical activities. The total testing process. Immediately after being collected, the diagnostic blood specimens need to be conveyed to the sites of testing, which can be allocated even at a very long distance from the collection site. Notably, the ongoing trend toward consolidating multiple areas of diagnostic testing (especially second and third line analyses) into larger diagnostic facilities has enormously magnified the challenges emerging from transportation of biological samples. Indeed, the more critical phases of shipment should be accurately optimized and standardized to ensure that the quality of the specimens is preserved upon reaching the testing sites, so that they can be used for producing reliable test results. Hand transportation for close distance, along with transportation by "wheels" (thus including motorcycles, cars, tracks and other motor vehicles) and even planes or helicopters for longer routes, have been the most popular means for transporting blood specimens throughout the relatively short history of laboratory diagnostics. However, remarkable advances have occurred in the past 20 years, thus making it possible to adapt newer technology for the purpose of shipping biological samples. A first and already consolidated approach was based on development of pneumatic transport systems (PTS), which were invented by the Scottish engineer William Murdoch in the 19th century for delivering letters, and then specifically redesigned to meet the handling requirements for laboratory samples, blood bags and drugs.

IRIZARRY, J., GHEISARI, M., WILLIAMS, G., & ROPER, K. (2014). "AMBIENT INTELLIGENCE ENVIRONMENTS FOR ACCESSING BUILDING INFORMATION: A HEALTHCARE FACILITY MANAGEMENT SCENARIO." *FACILITIES,* 32(3/4), 120-138.

ABSTRACT

Healthcare facility managers work in complex and dynamic environments where critical decisions are constantly made. Providing them with enhanced decision support systems would result in a positive impact on the productivity and success of the projects they undertake, as well as the sustainability of critical healthcare infrastructure. The purpose of this paper is to propose a conceptual ambient intelligent environment for enhancing the decision-making process of the facility managers. This low-cost data-rich environment would use building information modeling (BIM) and mobile augmented reality (MAR) as technological bases for the natural human-computer interfaces and aerial drones as technological tools.

Design/methodology/approach. This paper presents a scenario for the integration of augmented reality (AR) and BIM to build an ambient intelligent (AmI) environment for facility managers where mobile, natural, user interfaces would provide the users with required data to facilitate their critical decision-making process. The technological requirements for having such an intelligent environment are also discussed.

Findings. The proposed BIM-MAR-based approach is capable of enhancing maintenance related practices for facility managers who are mobile to integrate with their facilities' intelligent environment. This approach is also capable of providing a collaborative environment in which different stakeholders, across geographically distributed areas, could work together to solve facility management tasks.

Originality/value. In this paper, ambient intelligence will be considered for the first time in the area of healthcare facility management practices to provide facility managers with an intelligent BIM-based environment to access facility information and consequently enhance their decision-making process.

HAIDARI, LEILA A., ET AL. "THE ECONOMIC AND OPERATIONAL VALUE OF USING DRONES TO TRANSPORT VACCINES." *VACCINE* 34.34 (2016): 4062-4067.

ABSTRACT

Immunization programs in low- and middle-income countries (LMICs) face numerous challenges in getting life-saving vaccines to the people who need them. As unmanned aerial vehicle (UAV) technology has progressed in recent years, potential use cases for UAVs have proliferated due to their ability to traverse difficult terrains, reduce labor, and replace fleets of vehicles that require costly maintenance. Using a HERMES-generated simulation model, we performed sensitivity analyses to assess the impact of using an unmanned aerial system (UAS) for routine vaccine distribution under a range of circumstances reflecting variations in geography, population, road conditions and vaccine schedules. We also identified the UAV payload and UAS costs necessary for a UAS to be favorable over a traditional multi-tiered land transport system (TMLTS). Implementing the UAS in the baseline scenario improved vaccine availability (96 percent versus 94 percent) and produced logistics cost savings of $0.08 per dose administered as compared to the TMLTS. The UAS maintained cost savings in all sensitivity analyses, ranging from $0.05 to $0.21 per dose administered. The minimum UAV payloads necessary to achieve cost savings over the TMLTS, for the various vaccine schedules and UAS costs and lifetimes tested, were substantially smaller (up to 0.40 liters) than the currently assumed UAV payload of 1.5 liters. Similarly, the maximum UAS costs that could achieve savings over the TMLTS were greater than the currently assumed costs under realistic flight conditions. Implementing a UAS could increase vaccine availability and decrease costs in a wide range of settings and circumstances if the drones are used frequently enough to overcome the capital costs of installing and maintaining the system. Our computational model showed that major drivers of costs savings from using UAS are road speed of traditional land vehicles, the number of people needing to be vaccinated, and the distance that needs to be traveled.

GEORGE, A. (2013). "FORGET ROADS, DRONES ARE THE FUTURE OF GOODS TRANSPORT." *NEW SCIENTIST, 219*(2933), 27. [EXCERPT FROM ORIGINAL ARTICLE]

ABSTRACT

In rural parts of the world, building a reliable road infrastructure seems nigh impossible. Matternet's co-founder has another idea: vast networks of drones. You think that drones could help get vital supplies to the 1 billion people without reliable access to roads? That's correct. The key concept for us is a network of small drones. Alone, each of those vehicles could cover only a small segment of the transportation network, but together they can have a big spread. Why not build roads? Following the lead of road systems in the West is a nearly impossible task for the African continent. You're talking about a massive infrastructure investment and a huge ecological footprint. If you were to deliberately plan out an approach to transportation and logistics in Africa, would you do it in the same way? I'm convinced that the answer is no. Instead, I think you would use a few different modes of transportation – and one would be an aerial method like the drone network we're proposing. Won't a drone network be expensive too? For us, the most interesting thing happening with drones is in the super low cost category. The vehicles that you can buy today for $1,000 can do amazing things, and it's just the beginning of this technology. Instead of big machines, like the ones the military use, we're thinking small. So you're not thinking about mass transport of crops, but smaller items like medicines? Initially, it will be for medicine and diagnostics – things that are lightweight, high value. But over time, as the technology matures, there's a clear opportunity to move heavier loads. That's the big dream of Matternet – to become a transportation method that will allow economic growth. In your recent you said that drones could take HIV test samples from remote field clinics to a hospital.

CLAESSON, A., FREDMAN, D., SVENSSON, L., RINGH, M., HOLLENBERG, J., NORDBERG, P., ... & BAN, Y. (2016). "UNMANNED AERIAL VEHICLES (DRONES) IN OUT-OF-HOSPITAL CARDIAC ARREST." *SCANDINAVIAN JOURNAL OF TRAUMA, RESUSCITATION AND EMERGENCY MEDICINE,* 24(1), 124.

ABSTRACT

Background: The use of an automated external defibrillator (AED) prior to EMS arrival can increase 30-day survival in out-of-hospital cardiac arrest (OHCA) significantly. Drones, or unmanned aerial vehicles (UAV), can fly with high velocity and potentially transport

devices such as AEDs to the site of OHCAs. The aim of this explorative study was to investigate the feasibility of a drone system in decreasing response time and delivering an AED. *Methods:* Data of Global Positioning System (GPS) coordinates from historical OHCA in Stockholm County was used in a model using a Geographic Information System (GIS) to find suitable placements and visualize response times for the use of an AED-equipped drone. Two different geographical models, urban and rural, were calculated using a multi-criteria evaluation (MCE) model. Test-flights with an AED were performed on these locations in rural areas. *Results:* In total, based on 3,165 retrospective OHCAs in Stockholm County between 2006–2013, 20 locations were identified for the potential placement of a drone. In a GIS-simulated model of urban OHCA, the drone arrived before EMS in 32 percent of cases, and the mean amount of time saved was 1.5 minutes. In rural OHCA, the drone arrived before EMS in 93 percent of cases, with a mean amount of time saved of 19 minutes. In these rural locations during (n = 13) test flights, latch-release of the AED from low altitude (3-4 m) or landing the drone on flat ground were the safest ways to deliver an AED to the bystander and were superior to parachute release. *Discussion:* The difference in response time for EMS between urban and rural areas is substantial, as is the possible amount of time saved using this UAV-system. However, yet another technical device needs to fit into the chain of survival. We know nothing of how productive or even counterproductive this system might be in clinical reality. *Conclusions:* To use drones in rural areas to deliver an AED in OHCA may be safe and feasible. Suitable placement of drone systems can be designed by using GIS models. The use of an AED-equipped drone may have the potential to reduce time to defibrillation in OHCA.

SANDVIK, K. B. (2015). "AFRICAN DRONE STORIES." *BEHEMOTH-A JOURNAL ON CIVILISATION,* 8(2), 73-96.

ABSTRACT

The process of normalizing drones throughout Africa has received little scholarly attention. Discussions of drone proliferation tend to assume that the drone industry is a monolithic, geographically concentrated entity, and that drone use will look the same and engender the same controversies, regardless of geography. The article aims to think through African drone proliferation by analyzing how drones and Africa are being construed as solutions to each other's problems, and by exploring the interface between images of Africa and the notion of the drone as a game changer for development and security. The article also reads the African drone in the context of the early deployment of surveillance drones in Africa in the 1970s, as well as the legacy of technological imperialism and colonial airpower. The perception of Africa as being in need of external drone intervention dovetails with the drone industry's efforts to identify and promote good uses for drones — efforts that are central to increasing the legitimacy of drones in the eyes of the Global North. Hence, the article argues that the "African drone" has become a vehicle for the production and distribution of norms, resources and forms of legitimacy that have implications for drone proliferation, both within and outside Africa.

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- Personal correspondence between Helena Samsioe and Caroline Briggert (DJI) March - October 2016
- Personal correspondence between Helena Samsioe and Agnes Binagwaho (Rwanda Minister of Health) May 13, 2016
- Personal correspondence between Helena Samsioe and Will Hetzler (Zipline) May 2016
- Personal correspondence between Helena Samsioe and Nick Hu (Zipline) May - June 2016
- Personal correspondence between Denise Soesilo and UNICEF staff October 6, 2016
- Personal correspondence between Helena Samsioe and Brittany Hume Charm (Zipline) October - November, 2016
- Personal correspondence between Helena Samsioe and Israel Bimpe (GLOBHE Rwanda) October - November 2016
- Personal correspondence between Helena Samsioe and Dr. Kayumba (East African Center of Excellence for Vaccines, Immunization and Health Supply Chain Management, University of Rwanda), April - June 2016

ANNEX 1: LIST OF HUMANITARIAN UAV PROJECTS TO DATE[48]

Country	Date	Aim	Actors	UAV tech
Albania	2013-2014	The World Bank piloted the use of UAVs for multi-purpose spatial data capture including disaster risk mitigation.	World Bank	Multirotor (quadcopter) from Steadidrones
Australia	Annual challenge	The UAV Challenge is a joint project among the Queensland Government, the Australian Research Center for Aerospace Automation (ARCAA, a partnership between QUT and CSIRO), Aviation Development Australia Limited, and AUVS-Australia. The UAV Challenge has two categories: the airborne delivery challenge and the search and rescue challenge. In the former, which is open to high school students, entrants must develop a UAV to deliver a package to someone lost in the outback. In the latter, open to university studies and hobbyists, entrants must develop a system that can find a lost person and deliver a package to him or her.	Queensland Government, the Australian Research Centre for Aerospace Automation, Aviation Development Australia Limited and AUVS-Australia.	Various
Bhutan	2014	Matternet teamed up with the World Health Organization (WHO) to pilot the use of payload delivery via UAV.	Matternet, WHO	Matternet Quadcopter
Bosnia-Herzegovina	May-June 2014	Massive flooding led to an activation of the European Civil Protection Mechanism. In this context, the Belgian First Aid and Support Team (B-FAST) was deployed to Bosnia to help with relief operations. Along with the B-FAST team, two EU-research projects (ICARUS and TIRAMISU) decided to bundle their forces to support the relief operations. The Belgian Royal Military Academy (RMA) sent an Unmanned Aerial System (a MicroDrones MD4-1000) along with 3D mapping tools to assist the teams with tasks such as damage assessment, dike breach detection, mapping, aerial inspection, and relocating the many explosive remnants of war that were displaced due to the landslides.	B-FAST, ICARUS, TIRAMISU, RMA	Microdrones MD4-1000
Brazil	February 2016-present	The government, teams of troops, and civil servants in Brazil are using drones to detect and destroy the breeding grounds of the ***Aedes aegypti*** mosquito that transmits Zika, dengue and chikungunya viruses. Equipped with video cameras, the drones allow operators to spot potential breeding sites from air. São Paulo, Brazil's largest city, is flying drones over shuttered residences to check for signs of the mosquito in gardens, terraces, and other places where they might breed. The legislature of the west-central state of Mato Grosso has also approved a law to allow cities to use drones to combat the mosquito.	Government of Brazil	Multirotor

[48] List taken from UAViators website. An updated list can be found at: http://uaviators.org/docs.

Country	Date	Aim	Actors	UAV tech
Canada	May 2013	Royal Canadian Mounted Police used a Dranganflyer X4-ES drone to locate a driver of an automobile who had wandered off after an accident. Originally, a ground team and air ambulance helicopter with night-vision capability failed to locate the driver. After the cell phone of the driver was used to identify his general location, a Draganflyer X4-ES drone with heat-sensing equipment was then used to find his exact location.	Royal Canadian Mounted Police	Draganflyer X4-ES
China	2014	A team from DJI used UAVs to provide disaster responders with a bird's eye view of the damage from an earthquake, helping them prioritize their search and rescue efforts. The Chinese government also deployed UAVs to map and monitor a quake-formed lake that threatened to flood areas downstream.	DJI, Chinese Government	DJS S900, DJI Phantom 2 Vision+, other
Dem. Rep. of the Congo	January 2013-present	The UN Security Council approved the use of unmanned drones by the UN Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) in January 2013. The drones were officially launched in December 2013. MONUSCO is using them to promote peace and security, including assessing population movements, environmental challenges, and needs evaluations. The drones, which contain a camera with infrared and SAR capabilities, are based in Goma and are deployed across North Kivu.	MONUSCO	Falco
Dominican Republic	2013	Matternet builds drones to deliver food, medicine, and other necessities in developing countries to areas that are not accessible by road. They piloted a drone delivery program in Haiti and the Dominican Republic with three vehicles conducting missions in both urban and rural areas. The Haiti pilot focused on the delivery of diagnostic samples and the Dominican Republic pilot focused on courier transport. Both pilots included conversations with government officials and aviation authorities.	Matternet	Matternet drone
England	July 2013	Patterdale Mountain Rescue Team piloted the use of drones to aid in search and rescue efforts. The drones captured images that were then uploaded online to crowdsource the search and rescue efforts, with public users attempting to find injured people. Once a user identified a possible area of interest, this information was sent back to the rescue team which could then redirect the drone for a closer look. The drone relayed 100 images per minute.	Patterdale Mountain Rescue Team	Search and rescue drone
Ghana	2015-2016	UAV cargo trial in rural Ghana as part of the "Dr. One project" to transport contraceptives in collaboration with UNFPA, the Dutch Government, and the Ghana Health Service.	UNFPA, the Dutch Government, the Ghana Health Service	Hybrid
Haiti	2010	After the 2010 earthquake, an Elbit Skylark UAV was used to survey the state of an orphanage near Leogane, just outside the capital.		Elbit Skylark (fixed-wing) UAV

Country	Date	Aim	Actors	UAV tech
Haiti	2012	The United Nations Institute for Training and Research's Operational Satellite Applications Program used Sensefly's Singlet CAM to complete a mapping operation in Port-au-Prince. The operation, which only used images collected by the UAVs, produced an accurate map of an IDP camp. The results were provided to IOM. Further analysis was conducted on the data regarding construction areas, temporary housing, and debris hazards.	UNITAR, UNOSAT	Swinglet CAM
Haiti	2012	In Haiti, IOM has used drones to promote community resiliency and support disaster relief efforts. By using drones, IOM has been able to register lands, assess destroyed structures, conduct census surveys of public buildings, assess water quality, and monitor IDPs and camps.	IOM	SenseFly, Swinglet V. 1, DJI Phantom
Haiti	2012	During Superstorm Sandy, IOM used imagery to map trash dump zones, standing water that could affect public health due to the presence of mosquitos or epidemics, road conditions, water points, and latrines. This work has been done in conjunction with regular community engagement.	IOM	n/a
Haiti	April 2013	Drone Adventures deployed drones in Haiti, which they used to cover 45 square kilometers in less than a week. They mapped urban shantytowns in Port-au-Prince to count the number of tents and organize a census of the population. Additionally, 3D maps of dangerous terrain and river beds were used to plan infrastructure development. Drone Adventures worked closely with the International Organization for Migration (IOM) and Open Street Map.	Drone Adventures, IOM	Three eBee drones, computers running Pix4UAV by Pix4D
Haiti	2013	Matternet builds drones to deliver food, medicine, and other necessities in developing countries to areas that are not accessible by road. They piloted a drone delivery program in Haiti and the Dominican Republic with three vehicles conducting missions in both urban and rural areas. The Haiti pilot focused on the delivery of diagnostic samples and the Dominican Republic pilot focused on courier transport. Both pilots included conversations with government officials and aviation authorities.	Matternet	Matternet drone
Italy	2009	Quadrotor was used by the Sapienza University of Rome in the aftermath of the L'Aquila earthquake in 2009. Members of the University's Cognitive Cooperative Robotics Lab deployed the UAV on behalf of the L'Aquila Fire Department. The deployment in the debris concentrated on demonstrating mobility to fire and rescue agencies.	Sapienza University	Quadrotor
Italy	2012	The European Union fielded UAVs following earthquakes in northern Italy to assess the exteriors of two churches that had not been entered for safety reasons. The robots provided engineers and cultural historians with information that could not have been otherwise obtained.	EU	
Japan	2011	Following the 2011 nuclear disaster at the Fukushima Daiichi power plant, remote-controlled helicopters, specifically T-Hawk drones, were used to capture images of the damaged reactors for site assessments. The T-Hawk drone can capture standard and infrared images.		T-Hawk drone

Country	Date	Aim	Actors	UAV tech
Japan	2011	United States Anderson Air Force Base in Guam deployed a RQ-4 Global Hawk to assist disaster relief efforts for the earthquake, tsunami, flood and nuclear reactor disaster in March 2011. The Global Hawk was used to assess damaged infrastructure. The nuclear reactor disaster precluded people from staying in the area so UAVs were used to monitor the facilities. The Global Hawk assessed the effectiveness of efforts to cool the reactors.	U.S. Air Force	RQ-4 Global Hawk
Japan	January 2014	In January 2014, the Japanese Atomic Energy Agency and Japanese Space Exploration Agency began a one-year testing phase using a twin-tailed UAV. The UAV will provide real-time data about current radiation levels at the Fukushima Daiichi power plant.	Japanese Atomic Energy Agency, Japanese Space Exploration Agency	Twin-tailed UAV
Japan	2014	Drone Adventures teamed up with the Center for Spatial Information Science at the University of Tokyo to assess the state of the cleanup and reconstruction effort. Over the course of several days, they mapped three unique towns in Fukushima district: Lidate village, Hisanohama, and Tomioka.	Drone Adventures, University of Tokyo	senseFly eBees
Mediterranean	2015	MOAS (Migrant Offshore Assistance Station) used the Schiebel to rescue migrants at sea, a collaboration with MSF.	MOAS, MSF	Schiebel Camcopter S100
Nepal	2015	At least 15 independent UAV teams deployed to Nepal following the March/April earthquakes. UN/OCHA requested that all UAV teams check in with the Humanitarian UAV Network (UAViators) for information sharing and coordination purposes.	OCHA, UAViators	DJI Phantoms, DJI Inspire, senseFly eBee
Nepal	2015	GlobalMedic partnered with the Nepali Military Special Forces for Search and Rescue (SAR). The SAR mission objective was to locate a missing U.S. Marines helicopter that crashed in the mountains of Nepal. Extensive imagery of the vast forests and mountain landscapes were collected surrounding the focal point of the SAR operation. Both EO and IR imagery was collected.	GlobalMedic, Nepali Military	Aeryon Scout
New Zealand	2011	The University of Canterbury assisted the Canterbury Earthquake Recovery Authority (CERA) post-disaster recovery efforts by capturing aerial imagery of earthquake-damaged homes in the Port Hills area of Christchurch. Data were collected from areas that were unsafe to access to help CERA determine the best plan for demolishing the damaged homes and obtaining slope stabilization. The Draganflyer was also used to map the Greendale fault line in the Canterbury foothills.	University of Canterbury, CERA	The Draganflyer XP-4
Philippines	November 2013	Direct Relief's partner, Team Rubicon, used a Huginn X1 drone following Typhoon Haiyan to conduct visual analysis of damage to the Carigara District Hospital. Northwest of Tacloban, roads were damaged and the security situation was unknown. The assessment was then provided to local officials and aid groups, which allowed Team Rubicon to gather enough information to continue with setting up a medical relief station at the hospital.	Direct Relief, Team Rubicon	Huginn X1 drone

Country	Date	Aim	Actors	UAV tech
Philippines	2013-2014	Catholic Relief Services (CRS) teamed up with SkyEye to use UAVs for planning and project management following Typhoon Haiyan.	CRS, SkyEye	SkySurfer Fixed-Wing UAV
Philippines	November 2013	DanOffice used its quadcopter to identify areas to set up base camp and to assess damage from Typhoon Haiyan along the coast lines. The UAVs were also used to identify blocked roads and search for bodies in the debris (using thermal imaging cameras mounted on the drone for the latter purpose).	DamOffice	Huginn X1 drone
Philippines	March 2014	Medair worked with Drone Adventures to use eBee drones in Dulag town between March 7-16, 2014. The drones collected hundreds of aerial images of disaster-affected areas. The images created 2D and 3D terrain models. Medair used these maps to help determine the current need of affected communities and plans for assistance delivery. The images are free and publicly available online for other communities and humanitarian organizations to use.	Medair, Drone Adventures	eBee drones
Philippines	March 2014	Following Typhoon Haiyan, Swift Radioplanes LLC used Lynx Unmanned Aerial Systems (UAS) to collect thousands of high-resolution images over seven days. The images were compiled to create 3D maps that were provided to the Philippine government and the international academic community. This deployment was conducted in an area that the government had not yet assessed. Previously, the Philippine Department of Social Welfare and Development had to send staffers to remote villages to conduct damage assessments before they could give government aid to the affected areas. These assessment teams are understaffed and have an increasing workload. Use of drones can possibly help these teams conduct remote assessments.	Swift Radioplanes	Lynx Unmanned Aerial Systems
Philippines	January 2014	After Typhoon Haiyan, Humanitarian OpenStreetMap Team (HOT) called on those who used UAVs to provide the imagery to the OpenStreetMap community. HOT noted that little coordination between projects appeared to have occurred. They believed sharing this imagery was beneficial because many types of response and recovery organizations can benefit from these "bird's eye" views of the typhoon-affected areas. For example, this type of imagery allows the tracking of debris removal, the creation of detailed base maps, and helps in assessments to support timely, safe, and accountable reconstruction.	OpenStreetMap	Various
Philippines	2015	Within 12 hours after fires ravaged shantytowns, a UAV took aerial images for damage assessments, which helped to inform the city government on how many people would be affected and how to reroute traffic around the affected areas.		DIY fixed-wing with a Canon 110 camera
Solomon Islands	2014	SPC used a UAV to assess the extent of flood damage. The UAV was also used to map an area proposed for resettlement. In addition, the UAV was flown over a dam to assess potential damage. These flights were preprogrammed and thus autonomous.	SPC	Octacopter rotary-wing UAV

Country	Date	Aim	Actors	UAV tech
Tanzania	2015	The World Bank partnered with Drone Adventures to carry out a high-resolution aerial survey of Dar es Salaam for disaster risk reduction, specifically flood management. The imagery was collected to create digital terrain/elevation models for risk analysis and reduction.	World Bank, Drone Adventures	eBees, DJI Phantom 2 Vision+
Thailand	2011	UAVs were used in Bangkok following the Great Thailand Flood in 2011. These aerial robots were used to monitor large areas and allow disaster scientists to predict and prevent future flooding.		At least two multiple fixed-wing UAVs
United States	2005	Following Hurricane Katrina, two flights were carried out to determine whether people were stranded in the area around Pearlington, Mississippi, and if the cresting Pearl River was posing immediate threats. These affected areas were unreachable by truck due to trees on the road. CRASAR subsequently carried out an additional 32 flights with an iSENSYS IP-3 miniature helicopter to examine structural damage at seven multistory buildings.	CRASAR	AeroVironment Raven and iSENSYS T-Rex
United States	2007	The Ikhana drone, a 36-foot long version of the Predator drone, contains infrared sensors that were able to penetrate forest fire smoke and collect information such as size, intensity and directionality of wildfires. This thermal imaging information, used to create daily maps, was relayed to firefighters via satellite. Unlike satellites, drones are able to provide critical tactical, real-time information about quickly moving fires.		Ikhana drone
United States	May 2014	Angel Thunder was a joint-service, multinational, inter-agency search and rescue exercise held in the Pacific Ocean, New Mexico and the Grand Canyon in May 2014. The events simulated multiple deployment conditions. Attending participants included search and rescue personnel, special forces teams, and SAR experts. Rescue Global provided UAV platforms.	Angel Thunder	Various
United States	March 2014	On March 22, 2014, a major landslide occurred 4 miles (6.4 km) east of Oso, Washington when a portion of an unstable hill collapsed, sending mud and debris into a rural neighborhood, and covering an area of approximately 1 square mile (2.6 km^2). Forty-three people were killed. The Field Innovation Team, Roboticists Without Borders, and AirRobot helped enhance situational awareness for responders. 2D and 3D models of the slide area were generated to be used by incident command engineers for reconstruction and recovery.	Field Innovation Team, Roboticists Without Borders	AirRobot
Vanuatu	April 2015	The World Bank activated the Humanitarian UAV Network (UAViators) to recruit professional UAV teams and spearhead aerial surveys for disaster damage assessments.	World Bank, UAViators	Martin Lockheed Indago, DJI Phantom 2 Vision+, ALIGN 690L Hexacopter
Vanuatu	April 2015	The SPC used a Trimble UAV to collect high-resolution images to assess building damage. They also generated high-resolution topography of coastal areas to investigate wave and storm damage impact.	SPC	Trimble X5 UAV

ANNEX 2: HUMANITARIAN UAV CODE OF CONDUCT AND GUIDELINES[49]

In March 2014, UAViators drafted the first version of the Humanitarian UAV Code of Conduct to inform the safe, coordinated and effective use of UAVs in a wide range of humanitarian and development settings. This document was shared widely and publicly disseminated as an open and editable Google Doc to solicit feedback. The Code of Conduct was subsequently revised a dozen times in 2014 and reviewed again at the UAViators Experts Meeting on Humanitarian UAVs held in November 2014 at the United Nations Secretariat. In June 2015, UAViators actively solicited additional feedback from dozens of humanitarian organizations. In July 2015, UAViators organized an International Policy Forum on Humanitarian UAVs to further revise the Code of Conduct and to produce additional guidelines identified as priorities during the 2014 UAViators Experts Meeting. The Policy Forum was attended by experts from UN/OCHA, WFP, UNHCR, DPKO, ICRC, ECHO, American Red Cross, MedAir, Humanitarian OpenStreetMap, Cadasta, Peace Research Institute, Oslo (PRIO), Trilateral Research, Harvard University, Texas A&M, Pepperdine University, École Polytechnique Fédérale de Lausanne (EPFL), University of Central Lancashire, ICT for Peace Foundation (ICT4Peace), BuildPeace, DJI and other independent experts. These additional guidelines, listed below, address four key areas: data ethics, community engagement, effective partnerships and conflict sensitivity. In August 2015, the revised Code of Conduct and the new Guidelines were again reviewed internally by humanitarian organizations whose representatives participated in the Policy Forum.

These thoroughly revised documents are now being shared more broadly to solicit additional feedback. This open consultative process, which will include dedicated Webinars, culminated with the 2015 UAV Experts Meeting on Humanitarian UAVs, which is being co-organized with UN/OCHA, the World Humanitarian Summit (WHS) and MIT in October 2015. The documents were thus revised one more time at the 2015 Experts Meeting. Organizations that participated in the 2015 Experts Meeting include the American Red Cross, Direct Relief/NetHope, DJI, Doctors Without Borders (MSF), FHI 360, Swiss Foundation for Mine Action (FSD), GlobalMedic, International Organization for Migration (IOM), UN Population Fund (UNFPA), National Research Council of Canada, Rockefeller Foundation, UN Development Program (UNDP), UN Office for Coordination of Humanitarian Affairs (OCHA), USAID and World Bank.

In December 2015, feedback and comments received during this open consultative process and at the Experts Meeting were reviewed. An executive committee of five individuals from different organizations subsequently reviewed and integrated this input into the Code of Conduct and Guidelines on February 24, 2016. The donor community has already expressed a strong interest in this document and in being consulted once the process is concluded. It is our sincere hope that donors, UAV operators, humanitarian organizations and development organizations will stand by these guidelines and promote them publicly.

HUMANITARIAN UAV NETWORK CODE OF CONDUCT

Unmanned Aerial Vehicles (UAVs) offer the potential to improve humanitarian assistance and disaster reduction. As such, they offer the possibility to better meet the needs of those affected by humanitarian crises. This can only be realized if UAVs are employed in a responsible and ethical manner. This Code of Conduct aims to guide all actors involved in the use of UAVs to support the delivery of humanitarian assistance in disasters and situations of conflict. Acceptance and adherence to this Code will contribute to safety, professionalism and increased impact while building public confidence in the use of UAVs. The Code of Conduct will be revisited as experience grows and technology further develops. The UAViators Best Practice Report (available here) will also be updated as needed. Note that this Code of Conduct is a standalone document. The supporting, theme-based Guidelines are separate and distinct from this Code of Conduct.

The use of UAVs to support humanitarian action should be carried out for humanitarian purposes

[49] Taken directly from the UAViators website, where a constantly updated version can be found: http://uaviators.org/docs.

only and with the best interest of affected people and communities in mind, and should adhere to the humanitarian imperative of doing no harm. Naturally, how the guidelines below are applied may differ depending on whether UAVs are used to support humanitarian action in response to a natural disaster or armed conflict. That being said, UAV deployments in either context must observe the humanitarian principles of humanity, neutrality, impartiality and independence. UAV missions must also be legal, safe and have adequate insurance.

Prioritize safety above all other concerns: humanitarian benefits should clearly outweigh risks to persons or properties.

Only operate UAVs when more effective means are not available and when humanitarian purposes are clear, such as the assessment of needs and the response thereto. UAV missions should be informed by humanitarian professionals and experts in UAV operations with direct knowledge of the local context.

Respect the humanitarian principles of humanity, neutrality, impartiality and independence: prioritize UAV missions based on needs and vulnerabilities, make sure actions are not, and not perceived as being, politically or economically influenced; do not discriminate or make distinctions on the basis of nationality, race, gender, religious belief, class or political opinions.

Do no harm: assess and mitigate potential unintended consequences that UAV operations may have on affected communities and humanitarian action.

Operate with relevant permissions: UAV operations must be in compliance with relevant international and domestic law, and applicable regulatory frameworks including customs, aviation, liability and insurance, telecoms, data protection and others. Where national laws do not exist, operators shall adhere to the ICAO RPAS Circular 328-AN/190[50] with the approval of national authorities.

50 See: http://www.icao.int/Meetings/UAS/Documents/Circular%20 328_en.pdf

Engage with communities: community engagement is important and obligatory. Developing trust and engaging local communities encourages active partnership, builds local capacities and leadership and enhances the impact of your mission. Information should continuously be provided to communities regarding the intent and use of UAVs. Refer to Humanitarian UAV Network Community Engagement Guidelines.

Be responsible: contingency plans should always be in place for unintended consequences. UAV teams must take responsibility for and resolve any issues involving harm to people and property, including liability.

Coordinate to increase effectiveness: seek out and liaise with relevant local and international actors and authorities. UAV teams must not interfere with and always seek to complement formal humanitarian coordination mechanisms or operations.

Consider environmental implications: operating UAVs should not pose undue risk to the natural environment and wildlife. UAV operators must take responsibility for any negative environmental impact their mission causes.

Be conflict sensitive: all interventions in conflict zones become part of conflict dynamics and can result in very serious unintended consequences, including the loss of life. Extraordinary caution must be used in deploying UAVs in conflict zones. Refer to Humanitarian UAV Network Conflict Zones Guidelines.

Collect, use, manage and store data responsibly: collect, store, share and discard data ethically using a needs-based approach, applying informed consent where possible and employing mitigation measures where it is not. The potential for information to put individuals or communities at risk if shared or lost must be assessed and measures taken to mitigate that risk (e.g., limit or cease collection or sharing). Refer to Humanitarian UAV Network Data Ethics Guidelines.

Develop effective partnerships in preparation for and in response to crises: work with groups that offer complementary skill sets (humanitarian action, UAV operations, local context, data analysis, and communications) during, and preferably in advance of crises. Refer to Humanitarian UAV Network Effective Partnerships Guidelines.

Be transparent: share flight activities as widely as possible, ideally publicly, as appropriate to the context. Convey lessons or issues to communities, relevant authorities and coordinating bodies as early as possible.

Contribute to learning: carry out and share any evaluations and after-action reviews to inform the betterment of UAV use for humanitarian action.

HUMANITARIAN UAV NETWORK GUIDELINES ON DATA SENSITIVITY

The deployment of UAVs in humanitarian context should be carried out in a conflict-sensitive manner, in accordance with the best interests of affected communities, and with the humanitarian imperative of doing no harm. UAV deployments in humanitarian contexts must observe humanitarian principles of neutrality, independence, humanity and impartiality. In addition to observing humanitarian principles, UAV use should also comply with all laws and regulations and take into account considerations of public safety and insurance.

Naturally, how the guidelines below are applied may differ depending on whether UAVs are used to support humanitarian action in response to a natural disaster or armed conflict. Finally, these guidelines are linked to the Humanitarian UAV Network Code of Conduct and other supporting Guidelines,[51] all of which should be adhered to.

Collect and analyze data in a manner that is impartial to avoid discrimination. Informed consent should be secured insofar as the situation allows. As far as possible, data collection and analysis should highlight the needs and aspirations of vulnerable and marginalized groups.

Carefully determine need(s) before identifying an appropriate data collection platform. Then ensure that the data you collect is necessary and proportionate given the need you are intending to meet. When possible, data from UAVs should be used in conjunction with other data sources and not relied on exclusively.

Where appropriate and feasible, take reasonable measures to establish informed consent for data collection by UAVs. When consent could not be obtained, take extra care vis-a-vis sharing this data with respect to data privacy and protection.

Before you deploy, establish a plan for managing the data you will collect, including who will own the data, the standards you will use and whether it is interoperable with other systems and existing platforms. The overarching priority should be to mitigate risk for the individual.

Establish a plan for responsibly storing, sharing and discarding the data you will collect, including ensuring the security of storage and transmission of data.

Consider solutions for privacy and ethical sensitivities (blurring, virtual machines to query the data, down sampling).

Before deploying, conduct a risk assessment taking into account the context within which you will be operating, covering the data that will be collected and the tools that will be used.

Before collecting, sharing or storing data that is particularly sensitive, an assessment should be conducted to mitigate the risk and benefit. This can include religious and military sites and other information that may be considered military intelligence, and may also include other information according to the local context and the type of response, such as religious and critical infrastructure, pictures of the deceased, communication records or personal data.

HUMANITARIAN UAV NETWORK GUIDELINES ON COMMUNITY ENGAGEMENT

The deployment of UAVs in humanitarian context should be carried out in a conflict-sensitive manner, in accordance with the best interests of affected communities, and with the humanitarian imperative of doing no harm. UAV deployments in humanitarian

51 See: http://www.cashlearning.org/resources/library/389-protecting-beneficiary-privacy-principles-and-operational-standards-for-the-secure-use-of-personal-data-in-cash-and-e-transfer-programmes.

contexts must observe humanitarian principles of neutrality, independence, humanity and impartiality. In addition to observing humanitarian principles, UAV use should also comply with all laws and regulations and take into account considerations of public safety and insurance. Naturally, how the guidelines below are applied may differ depending on whether UAVs are used to support humanitarian action in response to a natural disaster or armed conflict. Finally, these guidelines are linked to the Humanitarian UAV Network Code of Conduct and other supporting Guidelines, all of which should be adhered to.

Communities should be consulted and information on how UAVs will be used should be provided. Community engagement (or social engagement) is thus important and obligatory. Building trust with local communities allows them to be active partners, decision makers and enablers, thus enhancing the mission and humanitarian/development impact.

Familiarize yourself with the local language(s), cultural norms and customs. Be sensitive to the fact that disaster-affected communities may be marginalized, discriminated against, suffering or traumatized and that the use of UAVs could cause more harm than good in conflict settings. Local livelihoods and access to basic necessities may also be disrupted.

Identify community representatives who are responsible for the geographical area you are interested in surveying. If the area is relatively small, seek local community representatives. Be aware that local representatives may not be so representative, as some communities may be marginalized and not represented. It's therefore important to seek to understand the local dynamics and to ensure that your approach doesn't discriminate against those who may be the most vulnerable or who may have the greatest needs. If the survey area is larger, seek provincial or regional representatives. Meet with relevant community representatives and provide them with your credentials such as business cards, a letter stating that you have legal permission from a government entity to operate UAVs, an official partnership letter from a humanitarian organization, etc.

Manage expectations; be clear that UAV flights may not immediately and tangibly result in aid or other forms of support. Explain the purpose of your UAV mission, why it is important, with whom the data will be shared, how it will be used, and how long this data will be retained. Show the technology and examples of aerial maps/imagery to ask permission to carry out the UAV flights. Jointly identify specific flight paths: what altitudes to fly, where and when. Ensure that marginalized areas are not ignored and that suggested flight plans do not represent conflicts of interest.

Be sure to ask whether any field-based disaster damage assessments have been carried out and whether any UAV teams/pilots (international, national or local) recently carried out any aerial surveys. If one or more teams have flown in the area, contact those teams to request the imagery or propose a sharing arrangement. Also ask which areas have been most affected and which areas should be prioritized and avoided (such as military and holy sites).

If community representatives grant you permission, then collaborate with them to publicize the mission, purpose and the proposed flight plans. Seek advice and make recommendations on how to leverage the tools to engage the community and support their needs and aspirations. Ask representatives to contact/inform the police so they are aware of the project and can assist with safety and information dissemination. Ask for guidance on how to reach out to local media (e.g., radio and newspaper) and influencers who represent diverse groups in the community including the most vulnerable groups. Produce flyers that provide an overview of your UAV mission and include contact information should community members have questions, suggestions, concerns and/or complaints. Schedule a public meeting with various civil society groups to present your mission, demo your technology and display examples of aerial imagery. This could also serve to dispel rumors, especially in conflict zones. Communicate risks and the process for documenting any incidents/accidents. Explain the proposed role of community members in potentially building UAVs, flying the UAVs and analyzing the data. Allow time for questions and answers during your public meeting. Finally, place signs up in areas where UAVs will be flying with the date and time of flight including your contact information.

For the safety of the community, please follow safety guidelines and best practices for UAV flights—see Humanitarian UAV Missions: Toward Best Practices.[52] Share incident/accident reports with local representatives and police.

Assess the potential for imagery or associated information to cause harm to the community (in whole or in part) and to humanitarians on the ground. Sharing information could exacerbate tensions within the community, for example, so measures must be taken to mitigate that risk including the option of not sharing information.

In line with the above, share your imagery both in printed and digital form with local representatives as soon as possible. At the very least, show the imagery collected by displaying it on your computer. (Naturally, this guideline may not be appropriate at all when operating in conflict zones). Ask these representatives for guidance on data privacy/protection preferences and use your best judgment. Encourage representatives to display hard copy images in public areas for all to see. Schedule another public meeting before you leave, sharing the results of your mission, any incidents/accidents and imagery collected. Explain the process for data removal. Allow time for question and answers. Refer to Humanitarian UAV Network Data Ethics Guidelines.

If the application of UAVs is for payload delivery, the same protocols listed above should be taken into account. For possible payload delivery in conflict zones, remote engagement may be an option but this may also pose dangers to at-risk communities. Please see guidelines below on Conflict Sensitivity.

HUMANITARIAN UAV NETWORK GUIDELINES ON EFFECTIVE PARTNERSHIPS

The deployment of UAVs in a humanitarian context should be carried out in a conflict-sensitive manner, in accordance with the best interests of affected communities, and with the humanitarian imperative of doing no harm. UAV deployments in humanitarian contexts must observe humanitarian principles of neutrality, independence, humanity and impartiality. In addition to observing humanitarian principles, UAV use should also comply with all laws and regulations, and take into account considerations of public safety and insurance. Naturally, how the guidelines below are applied may differ depending on whether UAVs are used to support humanitarian action in response to a natural disaster or armed conflict. Finally, these guidelines are linked to the Humanitarian UAV Network Code of Conduct and other supporting Guidelines,[53] all of which should be adhered to.

Relevant partnerships can be established between actors who need and provide humanitarian or development data and/or humanitarian or development cargo services (including national and local governments, the UN and NGOs).

For UAV operators/providers/volunteers looking for humanitarian partners:

In general, experience has shown that the most useful UAV uses in disasters are those uses that are carried out in partnership with a sponsoring organization or agency, where the UAV operator acts based on the needs of the sponsor organization who knows the overall context of the disaster. In the context of conflict, UAV operators must *only* operate in partnership and under the strict guidance of sponsoring organizations or agencies.

In disaster response and preparedness settings, UAV operators seeking a partnership should:

- Find a sponsoring humanitarian/development organization, ideally prior to a crisis.
- Develop your mission(s) in tandem with sponsoring organization efforts to assist the affected community and work through the sponsoring organization to engage with the community.
- Understand the context of the overall humanitarian emergency or development context and position yourself and your equipment as to not become a liability.

Some organizations will not have the capacity or ability to engage you in a conversation about the utility of

52 See http://www.UAViators.org/docs.

53 See: http://www.elrha.org/wp-content/uploads/2015/01/effective-partnerships-report.pdf.

your technology, particularly during crisis response. Be prepared to take no for an answer.

For organizations looking to partner with UAV groups:

- Assess utility of UAVs in addressing needs of affected communities and consider making partnerships prior to crises (standby partnerships, letters of mutual intent, MOUs, implementing partner agreements, etc.). In a crisis, be aware of local operators who are acting independently and in good faith and consider efforts to reach out to them to bring them into coordinated humanitarian efforts.
- Select a company or organization with compatible principles, taking note of the overall framework for operation of UAVs in humanitarian contexts outlined above. Prioritize partnerships with local operators. Transparency with respect to objectives and funding is important to gauge the suitability of partners. When exploring partnership possibilities, be sure to identify who will cover travel/shipping costs, import/export devices, secure insurance, obtain waivers/permissions, analyze the resulting data, etc.
- Define the terms and duration of your partnership, including responsible data management and interoperability, data protection, data ownership and publicity rights during and after the partnership has ended and other similar considerations. Remain cognizant of the fact that the prioritization of the affected communities necessitates both the identification and avoidance of any conflicts of interest as well as the invalidity of any considerations of third parties that would compromise the primary obligation to affected populations in any way.
- Define and discuss the risks for the organization and for the UAV operator. This includes the safety of local communities and staff as well as potential threats to overall mission accomplishment as well as financial and reputational risk.
- Clearly specify termination of contract clauses. Termination of contract is considered to be lawful when a legitimate reason exists to end the contract before the UAV mission has been completed.
- Establish adequate Standard Operating Procedures (SOPs), including day-to-day procedures for information sharing and reporting of flight plans, logs etc.
- To avoid disruptive and/or overlapping UAV flights and congestion of airspace, support humanitarian coordination efforts and clusters where they exist, including daily reporting of where and when operations are occurring.

HUMANITARIAN UAV NETWORK GUIDELINES ON CONFLICT SENSITIVITY

The deployment of UAVs in a humanitarian context should be carried out in a conflict-sensitive manner, in accordance with the best interests of affected communities, and with the humanitarian imperative of doing no harm. UAV deployments in humanitarian contexts must observe humanitarian principles of neutrality, independence, humanity and impartiality. In addition to observing humanitarian principles, UAV use should also comply with all laws and regulations and take into account considerations of public safety and insurance. Naturally, how the guidelines below are applied may differ depending on whether UAVs are used to support humanitarian action in response to a natural disaster or armed conflict. Finally, these guidelines are linked to the Humanitarian UAV Network Code of Conduct and other supporting Guidelines, all of which should be adhered to.

All interventions in conflict zones become part of the conflict dynamics and can result in very serious unintended consequences, including the loss of life. Extraordinary caution should be used in deploying UAVs in conflict zones.[54] These guidelines refer to the possible use of UAVs for humanitarian purposes in conflict zones. In other words, they do not refer to the use of UAVs for conflict prevention or peacekeeping (unless these intersect with humanitarian activities). In general, as with other humanitarian UAV deployments, UAV missions in conflict zones should follow the ICRC Data Protection standards,[55] the UN Guidelines on Confidentiality and Handling of

[54] This section addresses situations of armed conflict, both international and non-international as defined by IHL. The same principles and rules should be applied, mutatis mutandis, to other situations of violence that do not reach the threshold of armed conflict (riots, coup d'état, widespread violence, etc.). The existence of localized or low-level conflict, including at the intra-or inter community level, should also be considered.

[55] See https://www.icrc.org/eng/resources/documents/publication/p0999.htm.

Sensitive Information and the UNHCR Data Protection Policy.

In conflict zones, different bodies of law apply, such as International Humanitarian Law or International Human Rights Law. However, not all armed actors party to the conflict can be counted on to abide by these bodies of law. What follows are the specific principles by which UAV missions should also abide in conflict zones:

- Ensure that the sole purpose of all UAV missions is to strengthen humanitarian action, including protect the population and relieve suffering.
- Determine whether UAVs (armed and unarmed) are already being used by some of the parties to the conflict. If they are, this may make it difficult to distinguish between your UAVs and those used by the parties to the conflict. Your use of UAVs may thus create fear and also raise suspicions.
- Never accept tasks from armed actors party to the tensions or conflict, including the collection or sharing of information with them. Never carry payloads for them. Due diligence must be taken when interacting with any group in a conflict setting, including government authorities.
- Avoid engaging with local communities in person in conflict zones, as this may place them at greater risk. Remote engagement should be considered when appropriate and safe.
- Ensure that UAV mission staff have adequate insurance and require staff to take necessary training in basic security in the field. Ideally, the UAV operator should also have experience working with or alongside security forces.
- Ensure that a humanitarian actor has negotiated access with armed actors party to the conflict for your UAV mission.
- Ensure that all data transmissions and storage in or to conflict zones are secure and encrypted.
- Put in place protocols to manage UAVs captured by armed actors party to the conflict, including adequate markings and coloring, a disable function, destruction of the memory card and simultaneous remote recording of data.
- Ensure adequate action and communications to address local perceptions around the use of UAVs. Perceptions may include: Perceived as hostile by one or more of the parties to a conflict (regardless of your actual neutrality or impartiality); fear or hostility from local populations traumatized by conflict; and negative association with military operations (including counter-terrorism or peacekeeping operations). All of these perceptions could jeopardize or contaminate the humanitarian purpose.
- Conduct a risk assessment on whether local conflict-affected populations can be targeted as a result of UAV flights (data collection or cargo), and put in place appropriate mitigating actions (including deciding not to fly UAVs).
- Consider the (positive and negative) effect on conflict dynamics of using local UAV operators (e.g., negative: leaked or manipulated data, alternative uses, coercion of operators; positive: greater trust, local buy-in, sustainability).
- Consider the safety of the UAV team especially if located within the conflict area and dynamics. Be aware that they could be targeted or coerced. Seek the security advice of relevant international actors (e.g., DPKO units and/or UNDSS).
- Consider that domestic and international militaries operating in the conflict zone may be willing to share UAV data and capabilities, and consider on a case-by-case basis whether utilizing these military assets is in or can be perceived to be in contradiction with the humanitarian aim of your mission.

ANNEX 3: LIST OF CURRENTLY AVAILABLE UAVS (INCLUDING NON-CARGO)[56]

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Aerial Technology International	ATImapper V1	Fixed Wing			Uses Pixhawk, 3DR's widely adopted autopilot system
Aerialtronics	Altura Zenith ATX 4	Quadcopter	1.4 kg, 6 kg MTOW	Up to 30 mins	
Aerialtronics	Altura Zenith ATX 8	Multicopter	2.9 kg, 8.5 kg MTOW	Up to 35 mins	
Aeromao	Aeromapper EV2	Fixed Wing		1.5 hours	
Aeromapix	Bateleur	Fixed Wing		45 mins	
Aeronavics	Aeronavics BOT	Quadcopter	1.2 kg (5 kg MTOW)	30 mins	Beginner to advanced (RTF, modular setup)
Aeronavics	Aeronavics CX-600	Quadcopter		30 mins (90 mins with fuel engine)	4 hour training included
Aeronavics	NAVI	Quadcopter	1.2 kg (5 kg MTOW)	35 mins	RTF
Aeronavics	SKYJIB	Quadcopter	5 kg (16 kg MTOW)	15 mins with max payload	RTF
Aeronavics	ICON	Quadcopter	15 kg (25 kg MTOW)	20 mins with average payload	RTF
AeroQuad	AeroQuad Typhoon ARF Kit	Quadcopter	KIT build can lift a digital SLR	20-25 mins	Advanced (Comes in a kit)
AeroQuad	AeroQuad Cyclone ARF Kit	Quadcopter	KIT build can lift a digital SLR	Up to 1 hour	Advanced (Comes in a kit)
Aeroseeker	Aeroseeker Commercial/ Security	Quadcopter	500 g (1600 g MTOW)	25 mins	
Aerotestra	ATMK09	Quadcopter	2300 g		Runs off standard APM 2.6 Arducopter firmware, easy to learn/ use
AeroVironment	PUMA AE UAS	Fixed Wing		3+ hours	
AeroVironment	Qube UAS	Quadcopter		Up to 25 mins with payload	
Aeyron	Aeyron SkyRanger	Quadcopter		40-50 mins with EO/IR payload	
Aeyron	Aeyron Scout	Quadcopter	1000 mm diameter lens		Easy, simple point-and-click navigation and camera control systems

[56] List taken from UAViators, where a more detailed, updated list can be found: https://docs.google.com/document/d/1Uez75_qmIVMxY35OzqMd_HPzSf-Ey43lJ_mye-kEEpQ/edit.

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Aibotix	Aibot X6 V2	Hexacopter	2000 g (4600 g – 6600 g MTOW)	18 min+ flight time on a single 5000mAh battery	
Air Robot	AR100-B (Multiple Models)	Quadcopter		20 mins	
Airdroids	Pocket Drone	Tricopter	0.5 lbs		Intermediate (autopilots)
Allied Drones	HL 88 Nemesis	Multicopter	Various payloads available - see reference	>25 mins	
Allied Drones	AW1 E-Star	Fixed Wing	1.5 kg internal payload	1 hour	
Allied Drones	HL 48 Chaos	Multicopter	6.8 kg - custom payloads available. Onboard FPV	>35 mins	
Ascending Tech	AscTec Falcon 8	Quadcopter	0.8 kg	12-22 mins	RTF
BCB International	SQ-4 Recon	Quadcopter		45-60 mins	
Bormatec	Bormatec Maja	Fixed Wing	600 g	60 mins	Basics are necessary, but easy to fly and to handle
Cropcam	Cropcam	Fixed Wing	5 oz. to 1 lbs	1 hour	Intermediate to advanced, need to learn the software, fly rc, RTF
CyPhy Works	Parc	Quadcopter		12 hours (nominal)	
Danoffice	Culumbus One	Fixed Wing		2.5 hours	RTF
Danoffice	Huggin X1	Quadcopter			RTF
Delair-Tech	DT-26	Fixed Wing	600 g to 2 kg	4 hours	
Delta Drone	Delta X	Quadcopter	ICG® docking interface for payloads; company will customize for each use case	15 to 20 mins	Requires Airware training - to French standard
Delta Drone	Delta Y	Fixed Wing		45 mins	Requires Airware training - to French standard
Delta Drone	Delta H	Quadcopter	ICG® docking interface for payloads; company will customize for each use case	15 to 30 mins	Requires Airware training - to French standard
Desert Wolf	Wasp Aerial System	Helicopter		30 mph cruise, 63 mph top	
Desert Wolf	Bat Surveillance Drones	Fixed Wing		30-60 mins	

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
DJI	Phantom 2 Vision	Quadcopter	Camera included, no more than 1300 g payload recommended	13 mins	Easy to fly - Mobile phone FPV
DJI	Phantom FC40	Quadcopter	Camera included	12-35 mins depending on build (see site)	Easy to fly - camera is integrated into UAV
DJI	Flame Wheel 450	Quadcopter		12-35 mins depending on build (see site)	
DJI	Inspire 1	Quadcopter		18 min	
DJI	S900	Hexacopter		18 min flight time	
DJI	Spreading Wings S800 EVO	Hexacopter	2.3-4.3 g	12-22 mins	Advanced, assembly and wiring required (clear instructions/video), much room for customization
DJI	Phantom 3	Quadcopter	Camera included, no more than 1300 g payload recommended	25 mins	Easy to fly - Mobile phone FPV
DJI	Phantom 4	Quadcopter	Camera included, no more than 1300 g payload recommended	28 mins	Easy to fly - Mobile phone FPV
DreamQii	PlexiDrone X4	Quadcopter		25-29 mins	
Dronemaker	Skypatrol XL	Quadcopter	1.5 kg max	25 mins	Beginner
Dronemaker	Skypatrol	Quadcopter	2 kg max	25 mins	Beginner
Ecilop	Ecilop Easy Plus	Quadcopter	Under 600 g, 2.2 kg MTOW	25 mins standard, up to 40 mins industrial (~$786)	Advanced - Assembly and pairing required
Eli Airborne Solutions	Swan III	Quadcopter		6+ hours	
Eli Airborne Solutions	Elix-XXL	Quadcopter		50 mins	Easy - Hours of training
Event 38	E386	Fixed Wing		75 mins	
Event 38	E384	Fixed Wing		100 mins	Starter kit that includes everything needed to begin mapping
Fatdoor	Skyteboard 3G	Quadcopter			
Flint Hills Solutions LLC	FH-420	Coaxial	12 lbs useful load	40 mins	
Flint Hills Solutions LLC	FH-320	Coaxial	6 lbs useful load	20 mins	

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Flying Eye	Flying Eye Hexacopter	Multirotor	1.3 kg	15 mins	
Freefly	Atla6	Hexacopter	7 kg	Up to 45 mins (no payload)	
Freefly	Atla8	Multirotor	9 kg	Up to 35 mins (no payload)	
FreeX	FreeX SkyView	Quadcopter	N/A - can carry gimbal	45 mins hover, 1 hour cruise	Beginner, RTF (easy install)
Future Hobbies	Flip FPV	Quadcopter			
Game of Drones	Game of Drones Rugged Airframe	Quadcopter	Variable		DIY builds - depends on autopilot chosen
Ghost	GHOST Basic	Quadcopter		30 mins (20 mins with gimbal and GoPro)	
HawkUAS	AreoHawk Commercial Survey UAV	Fixed Wing		90+ mins	
HD Copter	EOS	Hexacopter			
Heli-Max	230si	Quadcopter			Beginner - Intermediate (requires flying)
Hobby UAV	Techpod RTF	Fixed Wing	2.25 lbs including battery		Beginner - Intermediate. RTF, fully assembled.
Hobbyking	H-King Darkwing	Fixed Wing			
HobbyKing	Skyhunter FPV UAV	Fixed Wing			
HoneyComb	AgDrone	Fixed Wing		25-50 mins (depending on wind speed)	
Hoverfly	LiveSky	Quadcopter	< 5 lbs		Single operator RTF
Hoverfly	Hoverfly Venu X4	Quadcopter	< 5 lbs		Single operator RTF
HoverThings	Flip Sport	Quadcopter		Up to 25 mins	
Hubsan	SpyHawk FPV Version 3	Fixed Wing	Built in camera (forward facing)	5-20 mins	Beginner - RTF
ImmersionRC	XuGong-10	Quadcopter		22 mph	Advanced - unassembled
ImmersionRC	XuGong-8	Quadcopter		20 mins (1500mAH and 6.7 kg)	Advanced - unassembled
Infotron	IT180	Coaxial	3 kg (5 kg with fuel engine)	15 mins	
Iron Drone	NDAVA XC8	Quadcopter	Up to 2.5 kg	30-45 mins	RTF, training included
Latitude	Latitude Hybrid Quadrotors	Hybrid		> 7 hours	
Lehman Aviation	LA500	Fixed Wing	GoPro, Sony A6000, FLIR VUE PRO	45 mins	
Lehman Aviation	LM Series				

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Lumenier	QAV540g	Quadcopter		Up to 12 mins with payload	
Lumenier	QAV400g	Quadcopter		Up to 8 mins	
Marcus UAV Inc	Zephyr2	Fixed Wing	1 lb	60 mins	RTF day of arrival, free 2-3 hour training available
MartinUAV	V Bat	Hybrid	5 lbs	90 mins	RTF
MartinUAV	Super Bat Da50	Fixed Wing	2 kg	10 hours max	RTF
Microdrones	md4-3000	Quadcopter	3 kg	Up to 45 mins (no payload)	Microdrones offers two full days of free training with every purchase of a flight. Generally, it takes just one day for customers to learn how to operate the systems. The free training also includes lessons in software and flight management systems.
Microdrones	md4-1000	Quadcopter	1.2 kg max	Up to 90 mins/ average 45 mins	Microdrones offers two full days of free training with every purchase of a flight. Generally, it takes just one day for customers to learn how to operate the systems. The free training also includes lessons in software and flight management systems.
Microdrones	md4-200	Quadcopter	0.25 kg max	Up to 30 mins	Microdrones offers two full days of free training with every purchase of a flight. Generally, it takes just one day for customers to learn how to operate the systems. The free training also includes lessons in software and flight management systems.
Microkopter	ARF OctoXL 6S12	Multicopter	4 kg	20 mins	Beginner, ARF kit just needs to be assembled
MicroPilot	MicoPilot MP-Vision	Fixed Wing	5 ounces to 1 lb	1 hour	Beginner to Intermediate, comes ready to fly, just 1 hour assembly, need to learn software
MLB Company	V Bat	Hybrid	5 lbs	90 mins	

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Multirotor	G4 Surveying	Hexacopter	2.3 kg	20 mins	
Multirotor	G4 Recon	Quadcopter	5-5.3 kg	50-90 mins	
Multiwii Copter	Carbon Scarab Vampire	Hexacopter	850 grams including LiPo		
Multiwii Copter	Scarab QUAD C Stealth	Quadcopter			
Multiwii Copter	Scarab FPV Reconn v3	Quadcopter			
Nuv Aero	NuvAero ThermalCopter	Hexacopter	12.8 lbs (5.8 kg) MTOW	10 hours @ 40 kts	
Nuv Aero	NuvAero PhotoCopter 6	Hexacopter	4.4 lbs (2 kg)	1.5 hours	RTF Package
OM UAV Systems	Baaz UAV	Fixed Wing	Options include: color camera gyro stabilized + tilt mounted, 10x zoom color camera gyro stabilized + tilt mounted, High def video with onboard memory 1280x720.	25 mins	Beginner to advanced
Only Flying Machines	OFM-650S v2 SuperX edition	Quadcopter	1.5 kg (3kg MTOW)	12-15 mins (no load)	Beginner (RTF, calibrated)
Only Flying Machines	OFM Seeker-450 v2 SE	Quadcopter	500 g	12-14 mins	Beginner (RTF, calibrated)
Parrot	Bebop2	Quadcopter	NA	25 mins	
Parrot	AR.Drone 2.0 GPS Edition	Quadcopter	Camera built into unit. Can mount a GoPro but flight performance will be limited	15 mins	Beginner
Photohigher	Halo 6 Midi	Quadcopter	4 kg	30 mins with Sony camera	Advanced, no transmitter, apm, batteries included
Pleiades	Spiri	Quadcopter		10-12 mins	
Precisonhawk	The Lancaster 5	Fixed Wing	1 kg	45 mins	RTF
Priora	Maveric UAS	Fixed Wing		45-60 mins	Training available
Priora	Priora Hex	Hexacopter	4.4 kg including battery	90 mins	Operator training available, no prior flight experience required
Priora	Priora Hex Mini	Hexacopter		9-10 mins (fully loaded)	Operator training available, no prior flight experience required
Prox Dynamics	PD-100 Black Hornet 2	Helicopter	Steerable EO camera (pan/yaw and tilt)	Up to 25 mins	
Pulse Aerospace	Vapor 35	Copter	5 lbs	45 mins hover, 1 hour cruise	RTF

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Pulse Aerospace	Vapor 55	Copter	11 lbs with drop mechanism	45 mins hover, 1 hour cruise	RTF
Quadframe	Foldable Pro Sixcopter frame	Hexacopter			
Quadframe	Foldable Pro QUAD/X8	Quadcopter			
QuadH2o	QuadH20 Multirotor	Quadcopter	Built in camera		Beginner to advanced (RTF or kit form)
Quantum Systems		Hybrid	2.5 kg		
Quest UAV	Q-Pod	Fixed Wing	1.2 kg	20-30 mins	
Robota	SuperNova	Fixed Wing	2 lbs max.	500 mm diameter	Easy to operate (everything included)
Robota	Triton	Fixed Wing	7 to 9 oz. max.	50 to 90 mins	Easy to operate (everything included)
Rotomotion	SR125	Helicopter	25 kg w/ standard battery load.	8-12 mins (can be longer with better battery)	Training available - fully assembled
Rotomotion	SR7 Parvus	Helicopter	2 lbs	60-120 mins	Training available - fully assembled
Rotomotion	SR20 Electric	Helicopter	2.2 kg w/ standard battery set. 4.4 kg with optional battery set	60-150 mins	Training available - fully assembled
RP Flight Systems	Spectra UAS	Fixed Wing	1.3 lbs		Intermediate - advanced
Sci.Aero	4Scight	Quadcopter			
Sci.Aero	cyberQuad	Quadcopter	800 g	31-60 mins	Training courses available
seaHex	seaHex	Hexacopter		15-20 mins	Easy, 3 mins startup video
SenseFly	albris	Quadcopter	Cameras included	22 mins	2-5 hours training. Autonomous flight - software training required but no piloting skills.
SenseFly	eBee	Fixed Wing	150 g	45 mins	2-5 hours training. Autonomous flight - software training required but no piloting skills.
Service-Drone	Mulitrotor G4 Surveying	Hexacopter	2.3 kg	20 mins	
Skybotix	CoaX	Coaxial	Inertial Measurement Unit (IMU), a pressure sensor, a down-looking sonar, three side looking sonar	40 mins	Advanced, ready to fly, programmable, open source

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Squadrone System	HEXO+	Hexacopter		15 mins	
Swift Radioplanes	LinxUAS	Fixed Wing	Up to 2 lbs	50-55 mins - additional tanks increase to 110 or 165 mins	Autonomous flight - software training
Tarot	Iron Man 650	Quadcopter		12 mins (20 mins max)	
Team Black Sheep	TBS Caipirinha	Fixed Wing	GoPro included in total weight (620 g)		Intermediate - Advanced (assembly required, customizable, meant for FPV)
Textron Systems	AeroSonde	Fixed Wing	9.1 kg	14+ hours	
Textron Systems	Shadow M2	Fixed Wing		60 mins w/100 g payload, 20 mins w/1200 g	
Transition Robotics Inc.	The Mocha	Hybrid			
Trimble	UX5	Fixed Wing	16.1 MP mirrorless APSC	50 mins	
Trimble	X100	Fixed Wing	10 MP compact	45 mins	
Turbo Ace	Turbo Ace Matrix-S Deluxe Kit	Quadcopter	2.5 lbs optimal, 3.5 lbs max (6.2/5.2 lbs with battery)		Advanced (requires pairing with necessary parts, assembly required), flight training available
Turbo Ace	Turbo Ace Matrix-S + Devo 10	Quadcopter	2.5 lbs optimal, 3.5 lbs max (6.2/5.2 lbs with battery)		Intermediate (assembly required, flight training available)
UAV Factory	Penguin C UAS	Fixed Wing		20 hours	
UAV Solutions	Talon 240G	Fixed Wing	25 lbs	8-10 hours	
UAV Solutions	Talon 120	Fixed Wing	2.5 lbs	2-2.5 hours	
UAV Solutions	Phoenix Ace LE	Quadcopter	0.5 lbs	> 1 hour w/3 batteries and 40 mins with 1 battery	
UAVframe	UAV CW4	Quadcopter			
Vanguard Defense Industries	Shadowhawk	Coaxial	10 kg	3 hours	
Vayu		Hybrid	2.2 kg		
Versa Drones	Versa X6	Hexacopter	2.5 kg		RTF
Versa Drones	Heavy Lift Octocopter	Octocopter	12 kg		RTF
Versa Drones	Patrol	Quadcopter	350 g		RTF
Viking UAS	Viking Sky Hunter v2	Fixed Wing		6-7 mins with Gopro	

Company	Model	Type	Payload	Flight Time, Distance or Speed	Ease of Use
Viking UAS	RTX-X6	Quadcopter	N/A but can carry gimbal + FPV equipment.	Up to 18 mins	Designed for FPV usage.
Viking UAS	Viking RX80	Quadcopter		Up to 18 mins	
Vulcan UAV	Multiframe Mantis & Black Widow	Multirotor	Camera mount adapters to fit PhotoHigher AV130 and AV200 camera mounts are available	45 mins	
Walkera	QR X900	Quad/ Hexacopter		Up to 25 mins (4 rotors)	Intermediate/Expert
Walkera	Tali H500	Quadcopter	N/A	Up to 25 mins	RTF
Xaircraft	X650	Quadcopter	1735 g max	12 mins	The X650Pro comes as a kit and requires complete assembly. Someone new to UAVs would take around 4-6 hours to build the frame and install all of the flight modules
Xerospace	LM-1	Fixed Wing	12 MP - 18 MP (RGB or NIR) Interchangeable	60 mins	Very simple

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