

In collaboration with  
Deloitte



# Medicine from the Sky

## Opportunities and Lessons from Drones in Africa

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# Contents

3	Foreword	21	4 Looking ahead – a case for drones in the fight against COVID-19
4	Executive summary	22	Challenges: widespread distribution of a vaccine
5	1 Drones for medical delivery in Africa	22	A look at today: using drones to deliver vaccines and other medication
6	Introduction	23	Drones and the COVID vaccine
6	History of drone programmes in Africa	24	Beyond the COVID vaccine
6	Emergency medical sample and supplies delivery	25	5 Conclusion
8	2 Case study: quantitative model of the medical, on-demand delivery use case	27	Appendix A: A 10-prong consideration framework
10	Paths to sustainable programmes	28	Technical feasibility and maintenance
10	Showing value using a cost-benefit analysis model	28	Supply-chain resilience
12	Three sensitivities: vendor selection, existing transportation costs and operating at scale	29	Ownership and financing
15	Discussion	29	Community sensitization and engagement
15	Health benefits example – post-partum haemorrhage	30	Workforce
15	Broader economic benefits	30	Government affairs and regulation
16	Other benefits	31	Legal and privacy
16	The path forward	31	Third-party partners
17	3 Investigation – enabling conditions for rapid adoption	31	Insurance
18	Establishing a need	32	Safety
18	Path to sustained economic viability	33	Appendix B: Additional use cases
19	Supporting policy and regulation	33	Aerial dispersion
19	Accessibility of the region	33	Aerial surveillance
19	Supply chain	34	Remote sensing
20	Community buy-in, education and outreach	34	Heavy-lift cargo delivery
20	Factors for success	35	Contributors
		37	Endnotes

# Foreword



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The COVID-19 pandemic has made visible to the global community many health inequities that have long been present. As we move through this crisis, it has become clear that the previous ways of doing things are no longer adequate. This has created opportunities for innovation, such as the historic success of creating new vaccines in record time. Now attention is turning to how we can ensure equitable access to these types of essential health materials.

Drones provide a potential avenue for ensuring that everyone, no matter where they live, has access to high-quality healthcare. Africa has been a global leader in the field of drones with the first national-scale drone delivery programme launching in Rwanda and the world's first drone delivery of COVID vaccines taking place in Ghana. African countries are showing the rest of the world the social and economic value that can be provided by this technology.

Despite these successes, there remain many unanswered questions about how to design a successful drone programme, where the technology can be best applied and how to measure the results. This report offers a framework for evaluating these issues, which are essential for taking full advantage of this technological revolution. Although the focus is on the African context, the lessons are applicable around the world.

Some of the biggest challenges identified relate to the need to evaluate the opportunity drones provide at scale. Small pilot projects were a good way to learn initially, but we must now move through the “valley of death” between pilots and large deployments where the economics of drone delivery can make sense. The question is no longer whether the technology is ready, but how to find sustainable business models for drone-enabled healthcare provision. This is intimately connected to creating the right policy environment and ecosystem for drones in Africa

and beyond. The needs of the current time are too urgent for us not to aggressively pursue how we can shape emerging technologies to meet the needs of all people – no matter where they live.

Unmanned Aircraft Systems have the potential to play a transformative role globally. This is particularly true in healthcare, where drones may be able to overcome challenges in infrastructure and logistics. The potential lives saved or improved by timely access to medicines, equipment and medical facilities should be a rallying point for industry and government. And although this young technology has not played a significant role during the current COVID-19 pandemic, the challenges of medical logistics have been highlighted during this past year and drones could be a critical tool for future health crises.

The possible benefits are even more dramatic in Africa and India, where industry and government have recognized the enormous potential to do good with drones and have invested in a number of early-stage technologies and programmes. In Ghana this past year, drones delivered COVID vaccines for the first time. In India, the World Economic Forum's Medicine from the Sky initiative is working with the state of Telangana for drone-based medical deliveries. While these are very encouraging trends, it is critical to recognize that the next leap forwards for the development of drones for healthcare will require government and industry working together across a range of issues and to develop business models that provide a more realistic economic foundation for drone operators.

With this in mind, Deloitte worked with the World Economic Forum to develop this paper as a guide to the key considerations and the realistic financial analyses that should inform how to develop a thriving drone ecosystem in Africa and globally. We believe that the world is at the beginning of a revolution in healthcare logistics and we hope this paper serves to advance that cause.

# Executive summary

This report explores drone delivery programmes in Africa, specifically those with medical use cases. Through information provided from stakeholder interviews, extensive research and a Deloitte-developed cost-benefit analysis model, this paper examines the factors and considerations that have the greatest impact on the success of a drone programme. Ever more relevant now due to the COVID-19 pandemic, this report also looks at the potential use of drones to help distribute vaccines and other future medical applications. Additionally, the report discusses how drones have been used historically in Africa for a variety of different use cases, and how those can be broadened with future applications to bring additional benefits.

This report begins in Section 1 with a brief history of medical drone delivery programmes in Africa. Section 2 is devoted to a case study utilizing Deloitte's quantitative model of the medical, on-demand delivery use case. This cost-benefit analysis model is based on a Monte Carlo simulation, which can be described as a simulation to understand the impact that random changes in day-to-day demand for medical goods has on drone flight activity. This simulation is designed to better understand the

costs and benefits of using drones for on-demand medical supply delivery, as well as an accompanying sensitivity analysis to identify the factors with the greatest impact on the success of a drone programme. Section 3 conducts an investigation into the enabling conditions for rapid drone adoption in Africa, while Section 4 explores the application of drone delivery networks to the distribution of vaccines and examines how this could be applied in Africa and other parts of the world. Section 5 concludes the report with an examination of how drone programmes could have far-reaching future benefits for the communities they serve.

Appendix A includes a consideration framework for building or sustaining a drone programme, with regards to technology feasibility and maintenance, supply-chain resilience, ownership and financing, community sensitization and maintenance, workforce, government affairs and regulation, legal and privacy, third-party partners, insurance, and safety protocols and processes. Finally, Appendix B highlights other use cases for drones in Africa, including humanitarian missions, commercial applications and heavy-lift middle-mile delivery.



1

# Drones for medical delivery in Africa



Source: Wingcopter

## 1.1 Introduction

As we enter a new era of advanced mobility that includes innovations once thought impossible, such as self-driving cars and advanced aerial mobility, one technology has been at the forefront: drones. In African countries, drones are saving lives through programmes developed by the public and private sectors. These programmes have positioned countries throughout Africa as leading examples of effective drone use for a variety of purposes, with an emphasis on medical delivery. In addition, the future holds economic promise for commercial cargo transport using drones, aerial surveillance for agricultural and industrial applications, and non-medical package delivery.

While African countries have had several successful pilot schemes and two countries have had national-scale deployments, this work must now scale to

maximize the benefits drones can provide. This means taking a comprehensive approach that enables individuals in African countries to take full advantage of their potential. Drones are a powerful medical tool, and lessons learned in Africa can pave the way for other large-scale programmes globally. Drones can prove beneficial on many fronts, including being used to address the COVID-19 pandemic. The pandemic stands to change the way people worldwide live and positions the world for a “Great Reset”, as vaccine development and distribution proceeds and economies begin to reopen.<sup>1</sup> Building upon successful pilots in African regions, programmes around the world may even be able to use drones to pursue safe reopening through assisting with vaccine distribution or grow economies in new ways through emerging use cases.

## 1.2 History of drone programmes in Africa

Drone use in African countries originated as far back as 2007; however, programmes began in earnest in 2016. These typically began as a pilot, or within a pre-established drone corridor. A few gradually expanded from interspersed, limited pilot programmes to more routine operations as drones proved beneficial and the operators learned the unique aspects of operating them in their region. However, even among some of the drone programmes that were able to prove that the technology worked and increased efficiency in

last-mile logistics, many could not secure enough follow-on funding to move beyond the pilot stage even if their value held promise.

The most widely known drone programmes in Africa have focused on the delivery of blood, medical supplies and vaccines, which is explored below, but other use cases exist as well, including aerial dispersion for pest management, aerial observation, heavy-lift cargo delivery and the opening of drone academies.

## 1.3 Emergency medical sample and supplies delivery

In October 2016, Zipline began delivering whole and componentized blood (red and white blood cells, plasma, platelets and cryoprecipitates) to remote hospitals in Rwanda. By 2019, this programme had expanded to nationwide service, with Zipline delivering 75% of the country's blood supply outside of the Rwandan capital of Kigali<sup>2</sup> to 2,500 hospitals and health facilities and 25 million people from six distribution centres that cover 100% of Rwanda and 50% of Ghana. Zipline is presently constructing four additional distribution centres, enabling coverage of 90% of the population of Ghana. Completing hundreds of deliveries per day, at each distribution centre, in all weather conditions, the service distributes blood and blood components, hundreds of essential medicines, vaccines and small medical devices.

In March 2020, during the COVID-19 pandemic, Zipline expanded deliveries to include personal

protective equipment (PPE) for doctors in remote areas and, notably, transport of COVID-19 test samples from rural hospitals around its distribution centres to laboratories in Ghana's two largest cities, Accra and Kumasi, making regular autonomous flights in densely populated areas. It also introduced community-level delivery to enable access to advanced care closer to patients' homes, allowing immunocompromised chronic care patients to adhere to treatment regimens without risking travel to hospitals during a pandemic. By March 2021, Zipline had expanded its existing vaccine distribution programme in Ghana, which distributed more than 1 million doses of vaccines in 2020, to include COVID-19 vaccine distribution to rural and exurban health centres. Within three days, Zipline had distributed its entire initial allocation of 11,000 doses of vaccine, representing 13% of Ghana's total vaccines administered in that period. Building on

these lessons, Zipline has plans to enable advanced drone delivery concepts in Japan, the European Union, and United States as well, including the US COVID-19 response where Zipline and Novant Health began delivering PPE to Novant Health hospitals in North Carolina in May 2020.<sup>3</sup>

In early 2020, the United Nations Children's Fund (UNICEF) managed a pilot project with Matternet in Lilongwe to explore the transportation of HIV samples.<sup>4</sup> Also, in 2020, students began attending classes at the newly established African Drone and Data Academy (ADDA) in Malawi to learn the skills necessary to work with drones. While the effort was initiated in 2016, students began to attend classes at the ADDA in early 2020.<sup>5</sup> In 2017, UNICEF worked with the government of Malawi to establish a humanitarian drone corridor focused on delivering emergency medical supplies, vaccines and HIV test kits. The corridor also served as a proving ground in which early industry movers explored using drones in emergency disaster response and to expand Wi-Fi or mobile phone connectivity.

In 2018, the German delivery company DHL partnered with drone manufacturer and service provider Wingcopter to run a six-month pilot in the Mwanza region of Tanzania. Drones delivered medical goods from the Medical Stores Department (MSD) in Mwanza to places that are notoriously hard to reach through traditional ground transportation, including the Ukerewe Island in Lake Victoria.<sup>6</sup> On the return trip, laboratory samples were transported to the hospital's rooftop on the mainland, which enables faster analysis and significantly reduced waiting times for patients. For example, a trip that would have taken six hours and spanned nearly 150 miles by truck or four hours by ferry could be completed in 40 minutes, travelling 37 miles by drone.<sup>7</sup> By using a tilt rotor drone with vertical take-off and landing capabilities (VTOL), the drone could arrive at its destination and return with no additional infrastructure needed, making it ideal for reverse logistics.

In late 2019, UNICEF established another drone corridor – in Sierra Leone – focused on reducing maternal mortality by delivering blood for post-partum haemorrhage. Sierra Leone's maternal mortality rate is

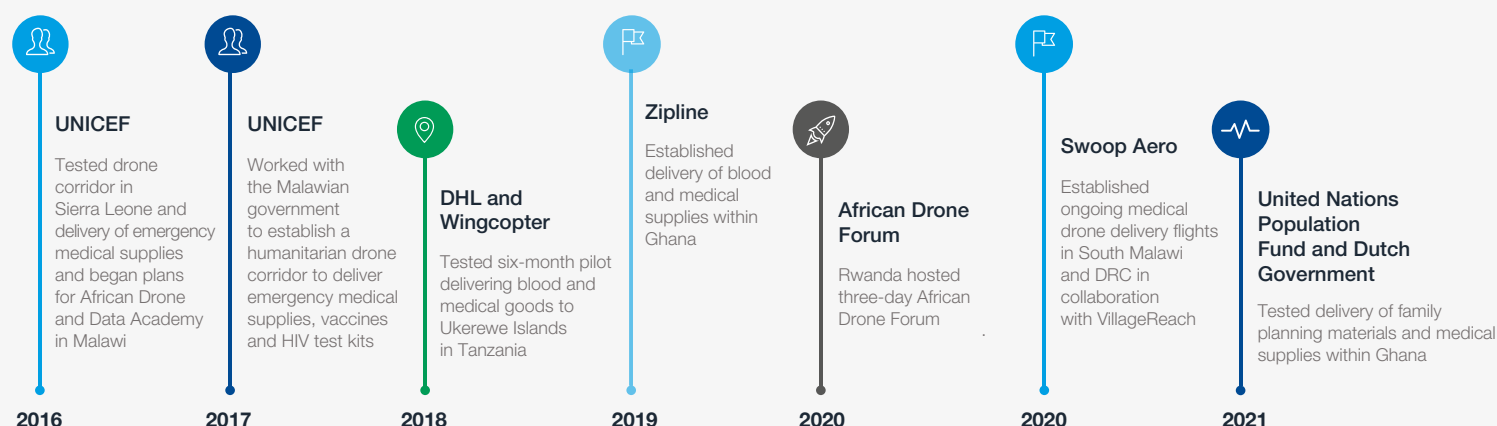
one of the highest globally, at 1,165 maternal deaths per 100,000 live births.<sup>8</sup> According to the Ministry of Health and Sanitation National Reproductive, Maternal, Newborn, Child and Adolescent Health Strategy 2017–2021, almost one-half (46%) of all maternal deaths are due to obstetric haemorrhage or blood loss.<sup>9</sup> The introduction of this corridor spurred the government of Sierra Leone to develop a regulatory framework to enable drones, specifically with applications in emergency medical delivery, disaster response and geospatial mapping.

In February 2020, Rwanda hosted the African Drone Forum (ADF) in Kigali. This three-day symposium aligned with the Lake Kivu Challenge, a flying competition in which 10 drone vendors competed to demonstrate different drone-based tasks. The ADF brought together government officials, regulators, international development experts, drone vendors and thought leaders from around the world to help facilitate a knowledge exchange among members of the international drone community. The World Economic Forum, a partner of the ADF, convened regulators from across Africa to advance the regulatory landscape on drones. The ADF emphasized the widespread applications and benefits of using drones, while examining regulatory, medical, technological and business needs holistically.

Recently, more African countries have started to implement drone delivery programmes in the healthcare sector. In addition to the programmes in Rwanda, Ghana and Tanzania mentioned above, Malawi launched programmes with the USAID Global Health Supply Chain (GHSC) Program in its northern region, Wingcopter in its central region and Swoop Aero in its southern region. Madagascar is working with Population Services International and Aerial Metric and the Democratic Republic of the Congo (DRC) is working with VillageReach.<sup>10</sup>

While much of the history of drone programmes in Africa has been focused on medical applications, other notable use cases exist. Policy-makers and the industry should explore these other cases (see Figure 1).

FIGURE 1 History of drone delivery in Africa



Source: Deloitte



2

## Case study: quantitative model of the medical, on-demand delivery use case



Source: LifeBank



Government agencies, international aid organizations and private donors have led medical drone delivery pilot programmes in Africa. While a few programmes have successfully grown from pilots to large-scale operations, moving into new markets and exploring new use cases, others have been halted due to lack of funding. The value proposition of on-demand drone delivery of medical supplies begins with the speed and range that they offer and extends to transforming the structure of medical supply chains and how care is delivered. At scale, an on-demand delivery system using drones can enable a healthcare system to significantly increase access to medical supplies while simultaneously reducing product wastage and cost, two objectives that often conflict. Such systems at scale obviate the need for decentralized storage of medical supplies and extensive cold-chain infrastructure, while at the same time enabling healthcare systems to more fully use all end points in their system with the confidence that they will not suffer shortages of medical supplies needed for treatment.

One of the most compelling use cases is last-mile, on-demand emergency medical delivery. Medical goods can be quickly transported to patients by drone, which is particularly beneficial when they are being carried to rural locations such as a remote health facility, or where drones can artificially extend the cold chain (dependent on specific storage temperature requirements). These programmes save lives and have a significant impact.<sup>11</sup> Delivering medical goods by drone in emergency or on-demand situations has clear benefits; the case of VillageReach's partnership with Swoop Aero explores what factors affect a programme's success, as well as how scaled operations lead to a compelling case for funding.

VillageReach offers an example of both the funding difficulties experienced by current unmanned aircraft system (UAS) programmes and the solutions to address them. In the Nkhata Bay region in northern Malawi, the USAID GHSC Program Procurement and Supply Management (PSM) project explored the use of drones for HIV/AIDS commodity deliveries to isolated and difficult-to-reach communities with two drone companies, Wingcopter and Swoop Aero. The project conducted eight months of drone deliveries to eight health facilities from July 2019 to February 2020. Subsequently, both companies have continued operations in Malawi, with Wingcopter covering the Central Region and Swoop Aero the south.

In February 2020, Frontier Technology Livestreaming, with UK Foreign Commonwealth and Development Office and UNICEF Malawi

funding, partnered with Swoop Aero to conduct another eight-month project servicing 38 health facilities.<sup>12</sup> Both Malawi projects successfully obtained Ministry of Health (MOH), district health office and local stakeholder buy-in, and both programmes were ready to scale. Unfortunately, the funding from international donors for both projects was short term. Given the workforce and operational investment already made by both the Malawi government and Swoop Aero, and the noteworthy progress for the drone ecosystem in Africa, the lack of continued funding presented the risk of a significant loss to both parties.

In response, VillageReach, together with Swoop Aero, developed a proposal for a phased national scale-up that would eventually reach 150–200 of the most difficult-to-access health facilities (representing about 20–25% of all health facilities in the country) and at least 3 million people. The progressive scale-up would link the established drone networks in the north and south with another middle network in a previously uncovered area and expand the benefits of the two regional networks. This proposal provided the Malawi government with a lower-risk option to expand the presence of drone programmes in its country through a longer-term approach that helped assuage any concerns over feasibility and viability, while simultaneously using previous government and donor investments to maximize the drone programme's impact.

VillageReach is currently helping the Malawi government to make the case for continued and expanded funding by emphasizing the programmes' existing benefits generated from the two previous programmes and drawing on the previous investments. While fundraising efforts are taking place, Swoop Aero and VillageReach have unified their efforts and, through self-funding, are sustaining operations in the southern region for a few more months to avoid flight interruptions at the facilities.

Wingcopter with support from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and in partnership with UNICEF and the African Drone and Data Academy (ADDA) has secured funding for an 18-month project to establish and expand drone delivery of medical supplies including COVID-19 vaccines to the central region of Malawi. With support from the Malawian Ministry of Health, Wingcopter is in the process of developing a delivery drone network that would cover a majority of the 7 million population catchment.

## 2.1 Paths to sustainable programmes

Data from numerous drone vendors and organizations involved in recent last-mile drone programmes indicates that many projects are financially challenged, despite having a substantial impact on local health outcomes. Many such programmes, including the one resulting from the partnership between the Government of Malawi and VillageReach, rely on funding from outside donors, such as international donor organizations (IDOs), or are otherwise supported by government funds. This funding is enough to establish a pilot, but it is often not enough to sustain the programme in the long term. Funding can diminish due to changes in administration, priorities or overall funding availability. Securing initial funding is often easier than securing continued funding in subsequent years.

One path to sustainability is securing funding as a service financed partially or wholly by a country or state health budget. The governments of Rwanda and Ghana allocated a permanent budget for Zipline's monthly operations through their ministries of health from the beginning of those services. Treating it as a healthcare delivery solution, these governments were able to pay for Zipline services by eliminating other upstream and downstream costs in their health systems. Zipline has secured similar state-level budgetary approval in its newly announced system in Kaduna state, Nigeria. Presently, Zipline claims operational profitability in its ongoing operation in Ghana. In some cases external donors are able to provide initial capital expense funding, which can be viewed as higher risk, while governments pay for operational expenditures. Over time a greater portion of annual expenses would be shifted to the health system receiving the service.

In cases where funding is limited or no longer available, drone programmes must find other ways to become financially sustainable. However, finding alternate sources of revenue to replace lost funding may prove difficult. For example, governments may not have funds set aside to sponsor drone

programmes that were previously otherwise funded, and there may not be another entity within the country that can intervene to provide additional support. Finding commercial partners or gathering grants from IDOs or other donor agencies may be possible but may not always be reliable in the long term. There may not be any suitable commercial partners in the region and relying on donor support alone trades reliance on the previous sources of support for reliance on donors without solving the underlying issue.

It is worth noting that drone operators are not the only supply-chain service providers that rely on funding from outside donors. In Africa, most health supply-chain services in most countries are in fact donor-funded, but donor procurement is geared almost exclusively toward traditional ground transport. Private-sector trucking companies thrive in this environment, but breakthrough supply chain technologies such as drones will not be widely adopted until donors, the predominant buyers of supply-chain services, adapt their procurement to allow multimodal systems to take hold.

Venture capital funding can also be difficult to secure, especially for smaller companies that are looking for immediate funding. The return on investment (ROI) may be uncertain to investors, especially in the case of a public good such as healthcare where improved health outcomes can be challenging to capture in strict financial terms. Since alternate funding and cost reduction are not viable for most programmes, maintaining continuous support is necessary. However, this support relies on quantifying the value proposition of using drones, which has been a struggle across the industry. Even for vendors that have data available, it can be difficult to effectively communicate and display the full scope of the costs and benefits of using drones. Deloitte's tool was developed to provide more insight in this area and provide clear metrics to investors on drone feasibility.

## 2.2 Showing value using a cost-benefit analysis model

To better understand the costs and benefits of using drones for last-mile on-demand medical supply delivery, Deloitte developed a comprehensive cost-benefit analysis model.<sup>13</sup> On-demand delivery was examined rather than routine delivery due to the additional challenges and complexity involved in the logistics, and because many of the compelling use cases for drones involve emergency delivery of critical medical goods that must be delivered as soon as they are needed, rather than sending them in fixed quantities on a regular schedule.

On-demand delivery also mitigates stock-out situations, where medical goods are out of stock at health facilities and thus unavailable for those seeking treatment. Stock-outs are common in many hard-to-reach health facilities, with some goods in certain areas being unavailable more than 80% of the time. This can be due to issues with either the overall supply of goods (not enough to go around) or the distribution of goods (supplies exist but not in places where they are needed). On-demand delivery by drone can combat stock-outs stemming from distribution

issues, since it allows for health facilities to request medical goods as needed, with rapid and reliable delivery from a central hub.

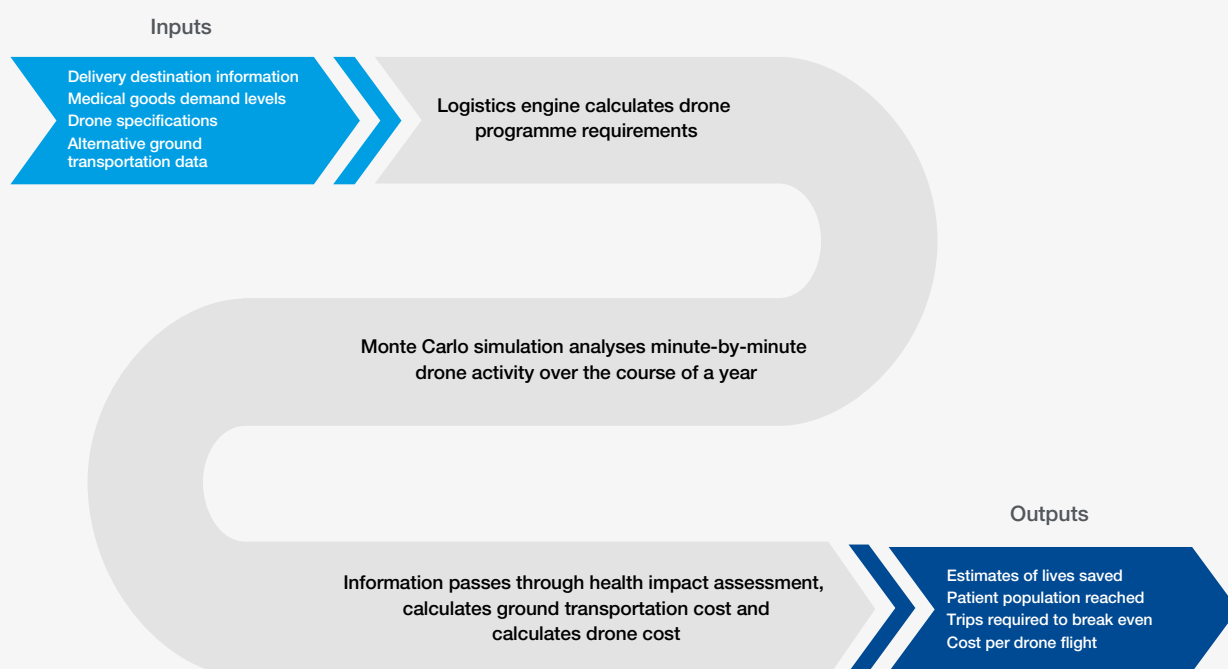
The model calculates key metrics including cost per trip, patient population reached, cost per life saved and number of trips required to break even. These metrics are driven by a logistics engine that simulates the requirements, including how many drones are needed, how many operators are required and the amount of ground infrastructure needed to support a programme of a given size. This is achieved by gathering user inputs on the number of potential delivery destinations, the distance to each destination, population covered, estimates on the per capita demand for each good being delivered and more. These parameters and estimated data points are used as an input for a Monte Carlo simulation to forecast the number of active drones needed so that a patient would never have to wait for emergency on-demand medical delivery. By crafting the logistics engine in such a way that drones are available to immediately respond to time-critical deliveries, delays and stock-outs can be almost entirely eliminated, assuming that the medical goods can be supplied from a medical supply depot in the region. The model then extrapolates the forecasted values to estimate

the logistical requirements (number of drones needed, trips flown, miles to be travelled) over the course of a year.

This logistics engine connects to an analysis of drone capabilities and costs that is compared against similar calculations for ground transportation, which takes into account the length and duration of each trip, and breaks the costs down into subcomponents (e.g. fuel and energy, maintenance, insurance, operator or driver pay). These costs vary in response to changes in user inputs. For instance, as more fuel-efficient modes of ground transportation are used, fuel costs decrease, assuming all else is equal.

The logistics information is also passed through a health impact analysis to estimate the number of lives saved by more rapidly delivering life-saving medical goods such as blood. This analysis is performed by modelling how a patient's chance of survival declines over time based on how long it takes to receive lifesaving treatment and compares the time to treat patients when using a drone compared to using ground transportation. It also considers how severe the patient's condition is, since a massive haemorrhage requires more rapid treatment to help the patient.

FIGURE 2 Cost-benefit analysis model methodology



Source: Deloitte

For a patient who is bleeding heavily, the difference between blood being delivered by drone in 30 minutes or being delivered by motorcycle eight hours later can be life or death. For a patient in a less severe condition, the difference is not so stark, but it is enough to have a sizeable impact on aggregate when looking at all health facilities and treatment goods being delivered. The model provides insight into the costs of operating a drone programme, the savings incurred by not using

ground transportation<sup>14</sup> and the health impacts on a population from expanding access to treatment and reducing the time required to obtain it. The result is a tool that can be deployed to transform growing drone programmes into long-term sustainable projects and gives decision-makers the information they need when assessing the investment required to use drones to improve public health.



## 2.3 Three sensitivities: vendor selection, existing transportation costs and operating at scale

For drone programmes to create value and survive in the long term, their benefits must outweigh their costs. This case study and accompanying sensitivity analysis is focused on the use case of on-demand medical delivery, typically in emergency situations; it is worth noting that the impact of the sensitivities may change with other use cases. However, the underlying results do indicate the power of scaled programmes given the low marginal cost of drone operations (once set up) and the dependence on existing transportation alternatives.

Given how convoluted the costs and benefits can be, in part due to the sheer number of variables

involved and lack of available data, many of the arguments in favour of drones are either incomplete or are made on a qualitative rather than a quantitative basis. After gathering data from existing drone programmes and vendors and analysing a variety of scenarios within the Deloitte model, it is evident that, under current conditions, many programmes do not provide a positive return on financial investment. To better understand the influence each input has on the overall net savings and number of lives saved, Deloitte performed a sensitivity analysis in which each of the inputs was varied by 10%, and then examined the change in model outputs. The results are pictured below.

TABLE 1 Deloitte sensitivity analysis summary of net savings and lives saved based on 10% change in inputs

Input	% Net cost reduction	% Increase in lives saved	Definition
Infrastructure cost	11.12%	0.00%	A 10% reduction in upfront capital expenses, excluding the drone itself
Ground transit mode	7.41%	0.00%	10% of trips switch from motorcycles to vans
Ground transit duration	7.18%	0.24%	10% of trips are delayed from eight hours to two days
Ground distance	5.01%	0.42%	Ground transportation must travel 10% further
Fuel efficiency	3.04%	0.00%	Drone can travel 10% further per unit of fuel
Drone purchase price	3.01%	0.00%	The cost to purchase the drone is reduced by 10%
Drone flight distance	2.97%	0.32%	The drone travels 10% less distance on each flight
Ground staff salary	2.89%	0.00%	Ground staff are paid 10% less salary
Operator salary	2.78%	0.00%	Drone operators are paid 10% less salary
Population/#cases	2.50%	10.22%	The number of cases is increased by 10%
Insurance cost	1.11%	0.00%	Cost to insure the drones and ground equipment is reduced by 10%
Ground equipment and maintenance	1.11%	0.00%	Ground equipment and maintenance costs are reduced by 10%
Battery/engine lifespan	1.01%	0.00%	Drone engine/battery lasts 10% longer
Avionics cost	0.33%	0.00%	Drone avionics cost 10% less
Battery/engine cost	0.23%	0.00%	Drone engine/battery costs 10% less
Avionics lifespan	0.20%	0.00%	Drone avionics last 10% longer
Drone speed	0.00%	1.68%	Drone flies 10% faster

### Notes:

1. Very large or small values can distort the percentage impact of inputs on savings and lives saved. For instance, a very expensive drone will see a much greater savings from a 10% drop in price when compared to a much cheaper drone.
2. The lives saved is minimally affected in this analysis since there is already a vast difference in survival rate curves between traditional and drone delivery, so a 10% increase in speed translates to arriving ~5 minutes faster, which has a much smaller impact than delivering to thousands more patients.

Source: Deloitte

FIGURE 3 | Deloitte sensitivity analysis percentage changes

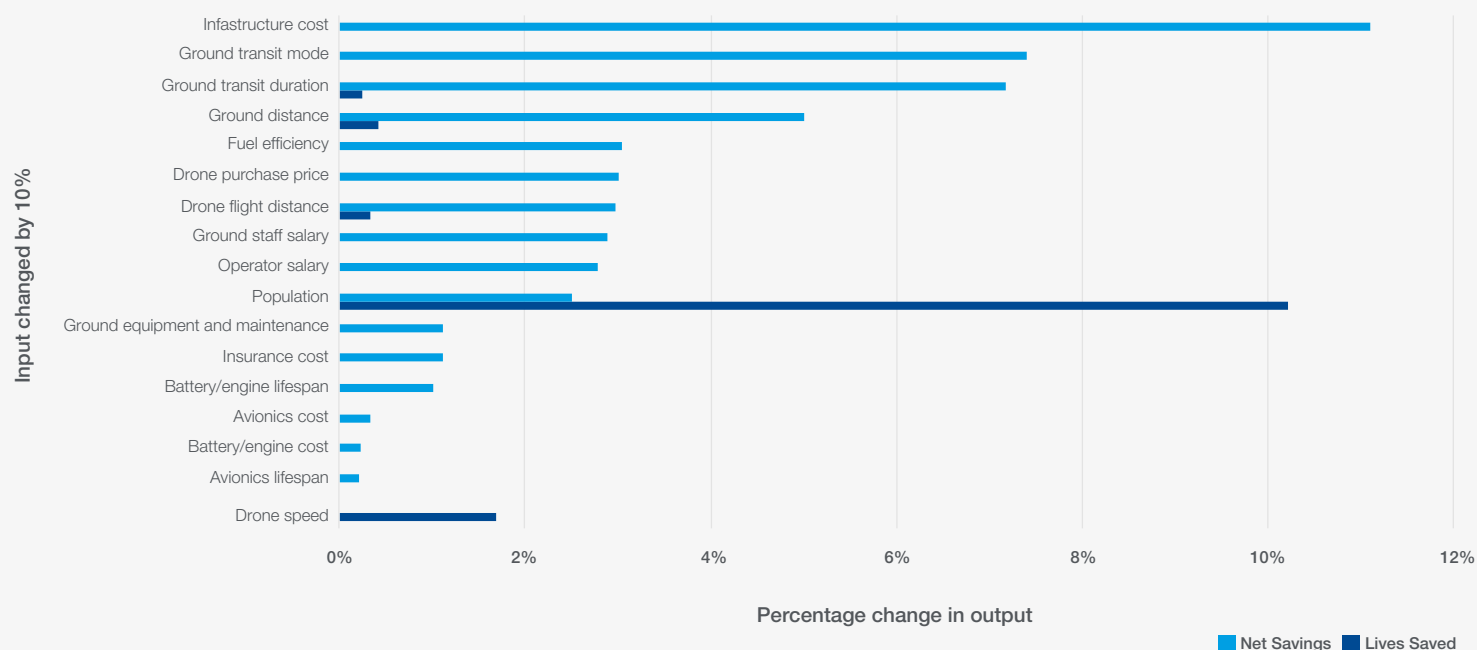


Figure 3 shows the percentage change in net savings and lives saved based on 10% change in inputs. This analysis was performed by rerunning the model after varying the value of each input individually, and then comparing the results to a base case with no changes. Net savings are improved the most by reducing infrastructure costs, setting up a drone programme in an area with expensive ground transportation, selecting an affordable vendor and scaling the programme. Lives saved is driven primarily by the population served by the drone.

Source: Deloitte

Immediately, infrastructure costs stand out as the most influential factor, which is to be expected. Given that infrastructure costs are often a substantial portion of overall costs, reducing them by a few percentage points can go a long way towards cutting overall costs and driving net savings. These costs are often front-loaded since infrastructure is frequently a prerequisite for beginning operations. However, infrastructure costs are highly variable, depending on the set-up of the programme. These costs could include those associated with drone ports, construction, landing pads, land fees, ancillary equipment, telecommunications equipment and more. Since requirements are so dependent on the scale of the programme, the use cases and the drone vendor, it can be difficult to draw generalizable conclusions. For those reasons, although the model indicates that infrastructure is the factor with the highest degree of sensitivity, it is often a factor that a programme can do little about.

This analysis also revealed that, for a drone programme to have net savings for the government, it requires three main factors: a drone vendor that is affordable enough and meets the requirements of the programme; ground transportation sufficiently expensive that savings can be realized by comparison; and a scale that is large enough that small per-trip savings can add up to a sizeable amount. The cost-effectiveness of a programme also depends on the magnitude of the health supply-chain challenges that can be addressed. If a country has persistent stock-outs, high wastage and expiry rates, and persistent quality-control issues, drones can drive more significant improvements regardless of the scale

of implementation. However, there was insufficient publicly available data to include that in this model.

When selecting a drone vendor for a programme, vendor prices and pricing models largely vary, as previously mentioned. Currently, two models prevail: drone-delivery-as-a-service (DDaaS), where a vendor offers drone deliveries as a fully managed service; and outright ownership, where a vendor offers a drone for sale, but does not provide the operations, leaving the purchasing programme responsible for all aspects of operation including finding qualified pilots, insurance, maintenance and other expenses. Therefore, depending on the priorities and capabilities of the programme, it is not always the cheapest vendor that is preferable.

Drone programmes are cost-effective when ground transportation costs are high enough that savings can be realized by using drones as an alternative. The cost of the vendor matters, too, however, and some will always cost more than ground transportation, preventing a positive return on investment under any circumstances. To provide an illustration, medical workers in some African regions deliver medical supplies using public transportation for free, since it is seen as a civic duty to provide aid. In this instance, even if the drone vendor is relatively affordable, it cannot compete on cost with free ground transportation.

Finally, drone programmes must also be executed at a large enough scale that small per-trip savings add up over time. The cost of sending a drone out on one more delivery is low in comparison to

the cost of setting up a drone programme from scratch. As a result, deploying drones at scale allows for lower marginal costs per trip. Scaling the programme allows it to reach a point at which the

average cost per trip will decline to a point where it is less expensive than the cost per traditional ground-transportation trip, which ultimately leads to savings over status quo transportation methods.

FIGURE 4 A scenario analysis of the same drone programme, scaled to different sizes

## Population and demand comparison

	Scenario A: 100,000 population 360 cases	Base case: 1 million population 2,000 annual cases	Scenario B: 10 million population 18,840 annual cases
Net savings	-\$132,134	-\$89,958	-\$318,766
Total yearly cost + infrastructure cost	\$173,914	\$238,255	\$730,059
Ground transport cost savings	-\$41,780	-\$148,297	-\$1,048,826

**Key takeaway:** The reason that drones scale well is because savings add up faster than costs. When the population increases by a factor of 10, traditional ground transport costs increase by roughly six times, while drone costs increase only twofold. This allows for large savings to be realized from not using ground transportation that offset the costs of the drones. However, it also means that having a prohibitively expensive drone, or cheap/free ground transportation will prevent drones from ever reaching a cost-competitive scale, no matter how many trips the drones make.

Scenario A represents a drone pilot; the base case represents a moderately sized drone programme; and scenario B represents a programme deployed at scale. Note that population and number of cases are not directly one-to-one because smaller programmes are traditionally aimed at underserved populations that will benefit more from the use of a drone delivery programme, compared to those that have better access to medical care and goods. Additionally, those in underserved areas may have a higher incidence of medical conditions that use medical goods delivered by drone, leading to a higher demand per unit of population.

Source: Deloitte

The scale of the programme may seem like a low priority based on the sensitivity analysis in Table 1. However, this is misleading, because the scale of the programmes spans multiple orders of magnitude, varying far more than just 10%. Figure 4 displays an analysis of a drone programme in three distinct phases of deployment: pilot; established programme; and countrywide full scale. For each scenario, the first row represents the net savings (negative values represent net losses). This is calculated by subtracting the total yearly cost and infrastructure costs in the second row from the ground transportation cost savings in the third row.

Many drone programmes fall under the first scenario, performing roughly one delivery a day. In some cases, a programme can expand and scale to perform tens of thousands of deliveries annually. Scenario B represents the deployment of a drone programme in an area that serves 10 million people, or roughly the size of the entire country of Rwanda. The net savings show that just by increasing scale, the programme moves from losing a significant amount of money to generating sizeable net savings. This is a critical insight because numerous drone programmes have lost funding and been cut off before reaching the scale at which they generate a positive ROI. Examining the financial sustainability of a small-scale drone programme is akin to looking at the profitability of a start-up in any other industry: in the early stages, the programme or company

will likely be losing money until it grows to a large enough scale after several years. However, unlike many start-ups, profitability is not the whole story, as drone programmes can provide immense value beyond just their cost savings, such as lives being saved and the creation of important infrastructure that can bolster other industries in the area.

When it comes to drone programmes, the industry is only beginning to unlock the true potential of a large-scale operation, which would be capable of generating substantial net savings and changing the lives of millions of people. In other industries, fledgling companies are given adequate time to develop and scale, but this has not necessarily been the case for most drone programmes, resulting in the premature cessation of programmes that might otherwise have realized net savings given more time and resources to reach a larger scale. In order to truly move the industry forward and realize the potential of these highly impactful programmes, they must reach a critical mass. If factored into their budgets, national and state governments can facilitate the growth of drone programmes by offering longer-term funding, or by stepping in to help bridge the gap when other sources of funding dry up. This can offer much-needed stability to help drone programmes take flight, while providing not only a positive return on investment but also numerous other benefits.



## 2.4 Discussion

While cost-benefit analysis is vital to attract investors and determine viability, drone programmes also provide value outside of net savings. They cater to a humanitarian need and improve quality of life, which is one aspect not considered in a traditional feasibility analysis. Drones can help expand access to medical treatments and provide more timely treatment. This applies to a wide variety of medical goods, including blood, vaccines, antivenom, viral load test samples, antibiotics and more. For many people, especially those in rural areas, access to these goods at smaller health facilities is sporadic at best, due to frequent stock-outs and wastage due to the lack of consistent power disrupting the cold chain. Furthermore, many medical goods have a shelf life: e.g. blood can be used for transfusion for five to six weeks only after it is donated, after

which it must be discarded because it would not have any positive effect and might even harm the patient if given in a transfusion. This prevents blood from being readily available at smaller health facilities, even though a lack of blood can have dire consequences. Furthermore, even if a health facility has some unexpired blood on hand, it may have only one or two units, which may not be enough to treat a patient who requires a massive transfusion. By ensuring that key medical goods are only a text message away, the quality and availability of medical care is greatly expanded, saving lives. With speed and on-demand delivery, drones can also enable a healthcare system to simultaneously expand access while lowering cost and wastage – goals that are typically considered in opposition to each other.

## 2.5 Health benefits example – post-partum haemorrhage

A perfect example is post-partum haemorrhage; this occurs when a woman loses more than 1 litre of blood after giving birth, which equates to roughly 15–20% of the mother's total blood volume. If left untreated, it can lead to heart strain, organ failure and death. It is the largest contributor to the estimated 200,000 maternal deaths<sup>15</sup> in sub-Saharan Africa; one-half of all worldwide deaths due to maternal haemorrhage occur in sub-Saharan Africa.<sup>16</sup> Depending on the severity of the haemorrhage, the mother has between 30 minutes and four hours to receive a transfusion.

In rural areas, blood may take several hours to arrive by motorcycle, if it is available at all. In comparison, a drone can deliver blood within 30 minutes, increasing a mother's chance of survival and subsequent quality of life. This could be further combined with other treatments such as oxytocin, which is used to help stop bleeding, making treatment even more effective. Drones have enormous potential to save lives; it is estimated that one-quarter of all maternal deaths in sub-Saharan Africa due to haemorrhage could be prevented by rapid access to blood transfusions.<sup>17</sup>

## 2.6 Broader economic benefits

A purely savings-driven cost benefit analysis does not capture the humanitarian value described above. Drones can be used to deliver blood for general surgery, vaccines to combat COVID-19 and much more, saving countless lives in the process each year. While the humanitarian benefits are most important, saving lives and improving access to health also drives economic value. Healthy

communities have more productive workforces, which can improve public finance and gross domestic product. When looking at the broader benefits of using drones, investment is more easily justified, since the broader economic benefits can be used to offset any investment required when discussing ownership and financing.

## 2.7 Other benefits

Using drones creates numerous broad social benefits, particularly with respect to a country's population, infrastructure and level of technology. For example, companies such as Zipline, Wingcopter and Swoop Aero exclusively hire local workers to staff their projects. This demand for local talent generates employment opportunities that develop transferable skills within the workforce. In Ghana, for example, Zipline currently employs 135 experienced pharmacists, flight operators, fulfillment operators and skilled engineers. This number is expected to increase to more than 200 by the end of 2021.

The skills from this workforce can be transitioned into other sectors of the economy, such as aviation and manufacturing. Operating drone services and drone manufacturing from within a country can also help create significant opportunities within the manufacturing and distribution parts of the supply chain. This would further expand the benefits to both local workers and further develop a country's skilled industrial workforce. Even if a drone programme is operational for only a few years, the skills developed during that time can be applied to future programmes within the drone industry or within broader industrial projects. However, this investment in manufacturing comes at an increased cost, and such funding could potentially be allocated to expand the coverage and scope of drone services instead.

Similarly, drone programme infrastructure can be multipurpose, as well. While a drone port may not see much use outside of its programme, expanding mobile phone service coverage creates tangible benefits. Since the requests for drone deliveries are often made by sending a short message service

(SMS) message, having reliable phone service is a prerequisite for delivering to an area. Given that drone programmes often focus on delivering to rural or hard-to-reach areas, mobile phone service may not always be reliable, requiring upgrades or expanding the coverage area. While this may be time-consuming and costly, such an implementation would bring clear spillover effects, illustrating how drones can be a catalyst for developing infrastructure. Without infrastructure needs being highlighted by the drone programme, the required investment may not have come to fruition.

The same can be said of technology, since the necessary technology to support a drone programme must either be developed or imported. While benefits will vary based on the programme, technological investment undoubtedly positions the country as a leader in that space, which can help attract future private investment. If a company sees that a government is willing to invest in technology, the company will be more likely to invest its own money to develop technology to bring to the area, creating a snowball effect whereby investment today can help bring investment tomorrow – a virtuous circle of investment. In this manner, drones can function as a leapfrog technology, where the more a country benefits from advances in technology, infrastructure and people, the larger the benefit is from using drones. While it can be difficult to put a price on the benefits of investing in the local populace, infrastructure and technology that a drone programme brings – in addition to the immediate health benefits – it is important to consider these elements when examining the programme's value.

## 2.8 The path forward

Advancing the use of drones requires much larger-scale programmes, even beyond the largest operations in place today. Without reaching a larger scale, drone programmes will remain limited. They will be hampered by a lack of return on investment, thus continuing the cycle that prevents government buy-in and private investment. By better understanding the costs and benefits, at both current and future levels, there is the potential for a long-standing, large-scale sustainable drone programme that can serve as the model for the industry in the future and help unlock the potential that drones hold. In future studies, health-impact data should be examined more closely to better understand the benefits of these programmes. Key metrics either do not exist or are impossible to evaluate easily. Of the little data available,

much may hold true for only one region but not another. Particularly for health data, much of what is available at remote health facilities is stored in paper records with limited information, making it difficult, if not impossible, to quantify the impact that drone deliveries have had on health outcomes. By improving record collection and centralizing record storage, it will be possible to better illustrate their health impacts. Collecting patient demographic information, medical diagnosis and treatment administered – and maintaining inventory records at medical facilities and supply depots, in particular – will allow for a better understanding of the impact that stock-outs have on the health of the local population, which can help make the case for employing drones for on-demand medical supply delivery.

3

## Investigation – enabling conditions for rapid adoption



LifeBank's drone operations in Ethiopia, 2019

Source: VillageReach

The rapid emergence and spread of COVID-19 created unprecedented challenges globally and led to sweeping efforts to try to curtail the spread of the virus. As a result, companies worldwide worked rapidly to develop innovative solutions that would address some of these new, unfamiliar needs. For instance, contactless delivery, or the ability to transport a good without requiring contact between two individuals, became increasingly necessary at a time when medical supplies such as COVID-19 tests and prescriptions were of critical importance.

Globally, some companies are looking to use drones for contactless delivery to counter some of the impacts of COVID-19. As many pilot programmes were rapidly initiated, operations met with varying degrees of success in terms of cost-effectiveness, direct impact and sustainability. While these rapidly realized programmes may have used some effective techniques, it became clear that other enabling conditions dictated the success and feasibility of their rapid adoption.



## 3.1 Establishing a need

One of the first steps in successfully implementing a drone programme is establishing that there is a need that can be fulfilled more cost-effectively or quickly by using drones. As drones are simply another mode of transportation that can be used to help a population achieve its needs, external factors must support the case for their use – particularly the fact that other modes of transportation would be insufficient. One example is Malawi. Throughout the country, many health centres and smaller clinics are difficult to reach and are typically some distance from the main health facilities (e.g. regional hospitals). As a result, these health centres, which provide vital healthcare to local populations, are accessible only by foot or bike. During rainy seasons, they become impossible to access and, as a result, many people become isolated and lose access to healthcare. As all other modes of transportation are unable to reach these areas, the need for drones exists: drones could access these areas to provide critical supplies.

Time constraints also contribute to creating an established need for a drone programme. For example, many Nigerian hospitals experience challenges delivering blood in a timely manner, despite excess supply. Blood also has a short shelf life, so deliveries need to be strategically timed. As a result, Life Bank has worked to build a platform to facilitate quick blood delivery between hospitals and doctors on demand, using multiple forms of distribution including motorbikes, small trucks, bicycles and drones. While motorbikes are readily available and effective when navigating difficult environments, drone delivery is significantly faster. LifeBank partnered with Wingcopter to demonstrate that in time-critical situations, such as the haemorrhaging mother example discussed in the previous section, drones are the best choice for fast delivery. Similarly, many remote communities in Africa lack proper infrastructure and are far from urban communities with access to amenities. As it takes too long to travel by car to reach these amenities, drones can help address access concerns in a timely fashion.

## 3.2 Path to sustained economic viability

Recently, government agencies, international development organizations and private donors have become increasingly interested in the applications of drones, particularly for health applications. Now, with the COVID-19 pandemic, this interest has surged – on the premise that a drone programme could rapidly deliver medical supplies to people who cannot afford the risk of an in-person encounter, or those who live in more rural areas. While this interest has initiated many conversations about drone programmes in Africa, it has also illustrated numerous problems. Much of sub-Saharan Africa lacks the necessary infrastructure to support drone operations, which has hindered efforts to quickly scale up drone programmes. This lag time between the inception and deployment of a drone programme due to infrastructure negates most of the potential benefits. While it is ideal to start contactless delivery by drone as soon as possible in Africa for humanitarian purposes, extended delays can be problematic for the drone vendors, with bigger implications for the entire industry, as such delays inhibit the path to sustained economic viability for full-scale integrated drone programmes.

Significant delays in drone programmes translate to a delay in realizing returns, and most are economically viable only at a large scale, as shown through the case study assessing on-demand medical delivery. A survey of leading industry stakeholders indicated that a drone programme may take a year to begin operations in a new region before beginning to scale up, which could take an additional six to nine months. This can create concerns for drone vendors that require financing from investors to bear the upfront costs in exchange for future returns. Dependence on investors, typically governmental organizations, creates pressure to generate revenue. Generating this revenue is unrealistic in the short term and can be uncertain in the medium to long term in the eyes of an investor or venture capitalist. Despite these challenges, it is important for those with the intention of establishing stable drone operations to solidify a path to sustained economic viability early in the life cycle of the programme.

### 3.3 Supporting policy and regulation

Without the support of the host country, drone programmes are impossible to implement. Therefore, many of the current successes are in countries with performance-based regulations that assess the safety of the specific operations an operator seeks to conduct, along with the benefits to the community the operations will serve. Governments with regulations and policies that support drones need to be ready to adapt them to different use cases. In Malawi, the Department of Civil Aviation has welcomed and promoted drone technology, enabling the nation to become a leading player in the African drone space. This support has been critical to the growth of programmes throughout the country. Malawi has also established new drone regulations for COVID-19 that will allow the release of funds more quickly in the event of a pandemic. In addition, new long-term regulations have been put in place for the minister of health to prepare for future pandemics, which further promote drone programmes for medical use.

Rwanda has also been forward-looking with regards to drone regulation. Rwanda initially formed its regulations using recommendations from the International Civil Aviation Organization (ICAO) and, over time, these regulations evolved to be more flexible in accommodating different missions and to be tailored to the Rwandan aviation environment. This supports the main goal of ensuring regulations do not negatively affect the industry and hinder operations. Supportive drone regulation enables Rwanda to participate in numerous programmes and pilots. As COVID-19 emerged, Rwanda's drone regulations also evolved in response to dealing with a global emergency by making it quicker and easier to get the necessary approvals to fly and increasing the number of flights to transport samples. Drone operations have scaled so significantly in Rwanda that Zipline's daily flight volume from its two distribution centres account for more than 10 times the daily flights from the international airport in its capital city, Kigali.

### 3.4 Accessibility of the region

From the perspective of rapid adoption, the initial conditions of the region in which a drone programme is going to be implemented can have profound impacts on the feasibility of initiating and scaling it.<sup>18</sup> Existing infrastructure, safety and geographical accessibility can contribute to the level of effort required to establish a programme. In fact, the most successful programmes operated where a significant amount of the infrastructure was already in place. The companies that attempted to begin from nothing could not bring their programmes to fruition.

A scaled drone programme will require significant infrastructure to enable it. This includes continuous

coverage on mobile phone networks, the presence of charging stations along common flight paths, the capacity to transmit radio signals and the capacity to receive or produce drone parts in the event of damage or replacement. The degree to which these capabilities already exist in sub-Saharan nations varies significantly depending on the region. These variables are already shaping the way drone operations are developed and designed. For example, where mobile phone or internet connections are unavailable, the drone may be equipped with satellite communications and be able to operate on a routine delivery schedule.

### 3.5 Supply chain

The travel restrictions imposed by COVID-19 demonstrated the need for a resilient supply chain for programmes in the healthcare space. As the manufacture of drones and their relevant parts largely does not occur within the African continent, existing drone programmes in Africa are dependent on foreign vendors. As a result, many existing companies leading drone programmes experienced significant supply-chain delays and costs because of the international travel restrictions. In the healthcare space, especially during the time of a global healthcare crisis, these delays and gaps

in service can unfortunately have significant impacts on the lives of the people in the community the programmes are serving.

For instance, three COVID-19 testing centres in Nigeria serve around 20,000 patients. Had operational drone networks been in place to supplement existing distribution efforts, Life Bank and the Nigerian government likely would have been able to respond faster to patient needs and provide necessary medical supplies.

Ideally, a sustainable and efficient supply chain would entail end-to-end operational independence. The programme would not experience any delays due to uncontrollable travel restrictions, and the costs would remain low, as the shipping costs would

be minimal due to locally available resources. For many companies, though, this is not workable due to a lack of resources, including parts, supporting technologies or staff with the necessary skills.

## 3.6 Community buy-in, education and outreach

While there may be an established need, an addressable market, appropriate government regulation and additional factors that would support a drone programme, local community buy-in remains crucial for its effectiveness.<sup>19</sup> In many cases, creating an outreach message and educational campaign to help raise awareness of the purpose and benefits and address any questions with the population can directly affect success.

As many rural populations may be unfamiliar with or have concerns about drone technology, obtaining community buy-in prior to establishing a drone programme and implementing its use is critical. Researchers from the non-profit organization FHI 360 sought to better understand perceptions of drones by citizens and government officials in Tanzania. To facilitate this, they conducted a variety of interviews and observations on initial perceptions of drones regarding their safety, purpose, use cases and regulation.<sup>20</sup> Although concern among citizens surrounding drones was generally low and included hesitation regarding accidents, privacy and security, only 24% of respondents had heard of drones prior to the study. This study stresses the importance of community engagement at the citizen level.<sup>21</sup> Some examples of community engagement include demonstrations and radio programmes to promote awareness and educate various populations on the technology.

Community engagement on issues such as privacy and safety are also challenging. For example, UNICEF conducted “drone days”, at which members of the local community could learn about drones and ask questions to see how deliveries were performed. This

enabled UNICEF to clarify that these drones were being used to benefit the community. UNICEF also has guidelines outlining clear use policies for operators regarding information, including a mandate to always ask permission before taking pictures and to explain to the community what they will do with the images. Similarly, Wingcopter personnel often travel to the villages where medical supplies will be delivered to present the drone technology to local community leaders as well as the health centre staff and patients. This creates awareness before deliveries begin. This community engagement provides early acceptance and even advocacy of the technology by the community leadership.

Zipline’s commitment to having operations staffed 100% locally helps encourage community buy-in and ensure positive perception of drones. The hope is that having 100% local operations will lead to an increased use of drones and provide more economic stability in the local areas of operations. Community perception of Zipline has shifted over time, as communities were initially concerned and apprehensive about drones; however, in many areas, the use cases have contributed to locals wanting to work in operation centres. In addition, one early concern among locals was that drones were collecting information on them.

Finally, as evidenced by the work undertaken by Swoop Aero, conducting a successful drone programme is much easier when the entity has partners on the ground. Without the local expertise that those partners bring, there would likely be confusion among communities about the purpose of the programme, especially as most drone companies operating in Africa are foreign.

## 3.7 Factors for success

Many factors greatly contribute to the feasibility and success of a drone programme in the medium to long term. These factors can be attributed to the political, social and geographical landscape of a particular region of interest, as well as the specific use case for the drone being explored. However, if the factors discussed above are present, then it is likely that a drone programme has a higher

likelihood of succeeding in that environment. Likewise, if the factors discussed are not present, then the drone programme operator and team will need to work to support those factors or find alternative ways to create a favourable environment in order to have a successful drone programme.



4

## Looking ahead – a case for drones in the fight against COVID-19

The DRC minister of health (middle), World Health Organization representative, and governor of Equateur visited the VillageReach office in Mbandaka to meet with Swoop Aero's CEO and drone operators.

Source: VillageReach



The COVID-19 pandemic has shaken the entire world. The biggest health crisis of our time, this pandemic has brought with it an increased reliance on technology. Drone industry experts have begun evaluating if drones could be used to tackle logistical challenges associated with widespread vaccine distribution as vaccines become available globally.<sup>22</sup> This falls in line with the thinking behind the Forum's "Great Reset":<sup>23</sup> a major crisis, the COVID-19 pandemic, has created an urgent

need for global stakeholders to cooperate in managing the crisis – governments, pharmaceutical companies, drone operators and others are collaborating to explore how to swiftly distribute a vaccine critical to the health of entire populations. A key tenet of the Great Reset is that this event could catalyse the adoption of technologies that were already on the horizon, a paradigm where drone technology fits in well.

Could our experience with the COVID-19 crisis catalyse long-term drone use? To explore this, much discussion is needed on the following topics: the logistical challenges of widespread vaccine distribution; how drone technology could be applied

(including how drones are already being used to fight COVID-19); what it would take to scale such an operation; and the continued use of drones beyond the distribution of a vaccine.

## 4.1 Challenges: widespread distribution of a vaccine

Before exploring how drones can be used to distribute a COVID-19 vaccine, it is important to examine some of the main challenges to widespread vaccine distribution – regardless of the distribution method. These include the vast number of people to whom the vaccine needs to be distributed and the need to find appropriate storage for a vaccine as well as an effective and efficient means of managing its distribution.

It is estimated that to vaccinate 60% of its population (the estimated minimum required for herd immunity), Africa will need about 1.5 billion doses.<sup>24</sup> Since 1977, the World Health Organization's Expanded Programme on Immunization has helped vaccinate millions of children.<sup>25</sup> However, adults also need the COVID-19 vaccine, so the infrastructure in place to vaccinate children will not meet the scale of this greater demand. In addition, some available vaccines require multiple doses, which adds to the number of units to be distributed.

To add more complexity, the distribution and storage of some of the vaccines in use require an extremely low-temperature cold chain. A cold chain is a logistical network with adequate refrigeration at every step in the supply chain, from the time it is manufactured to the time it is used. This process is designed to keep goods in their safe temperature range. Many foods, chemicals, pharmaceuticals and consumer goods (e.g. photographic film) require cold chains. Due to infrastructure challenges in Africa, cold-chain storage is lacking in many parts of the continent.

With so many people requiring the vaccine, the distribution scheme needs to ensure that very few or no vaccines go to waste. Problems with oversupplying some medical facilities while undersupplying others will result in poor distribution of the vaccine. Poor distribution could lead to the vaccine being wasted in some communities, while leaving other communities undervaccinated. This is especially problematic with a vaccine that is in extraordinarily high demand.

## 4.2 A look at today: using drones to deliver vaccines and other medication

The use of drones in fighting COVID-19 is an emerging use case. Drones can be effective in meeting the specific challenges of transporting and delivering medical supplies such as vaccines and PPE. However, given the unique challenges of widespread distribution, transportation of medical supplies including vaccines and PPE using drones could provide solutions.

Drones are already being used in Africa to deliver vaccines to protect against diseases other than COVID-19. In 2020 alone, Zipline delivered more than 1 million doses of vaccines, stepping up its vaccine delivery cadence significantly in response to limitations in healthcare access caused by COVID-19 restrictions. Building on its existing nationwide delivery infrastructure, Ghana then turned to Zipline in March 2021 to begin distribution of COVID-19 vaccines to rural and exurban healthcare facilities. Zipline has equipped all of its distribution centres with ultra-cold-chain storage capability, and has partnered with a leading vaccine manufacturer to develop cold-chain-specific packaging. Additionally, Swoop Aero has

been delivering vaccines in southern Malawi since early 2020 and started delivering vaccines routinely in remote rural parts of Equateur province in the DRC with VillageReach and the MOH at the end of December 2020.

In another example, drones helped bring medication to patients in rural areas, showing the reach that drones can enable. In a separate partnership between Zipline and Novartis, another pharmaceutical company, drones are used to deliver hydroxyurea to patients with sickle cell disease.<sup>26</sup> In Ghana, about 15,000 babies are born with sickle cell disease each year.<sup>27</sup> In the Zipline-Novartis partnerships, drones help bring medicine to rural communities. In one instance, drones were used to bring hydroxyurea to a child patient and his mother who would otherwise have had to travel five hours by bus to receive treatment. Similarly, Swoop Aero has been delivering ARVs (HIV medicines) in southern Malawi since early 2020. In partnership with VillageReach and the MOH, it will also soon begin to deliver second-line therapies that cannot be stored in health facilities for multidrug-

resistant TB and paediatric ARVs in Equateur and other areas in the DRC. The ability to bring medicine to people who might otherwise have to travel significant distances to be treated removes a significant barrier to the treatment of patients in rural areas. Likewise, the capacity to collect lab samples and have them tested swiftly can reduce the spread of infectious diseases, and drones are an expedient way to move samples to testing centres.

Leaving individuals unvaccinated creates unique public health challenges. If individuals who attend clinics to be vaccinated are sent away unvaccinated, they may not come back for a vaccine at another time because it takes time and effort to travel to the clinics. Another challenge exists regarding multiple-dose vaccines and the spacing required between doses. Typically, vaccines that require multiple doses are administered according to a schedule. If a person misses a dose and too much time elapses between doses, he or she may need to start treatment again from the beginning. This leaves individuals at risk of disease while also wasting both vaccines and time.

With drones, Novartis was able to distribute vaccines more efficiently, enabling them to serve

a larger population. In its partnership with Zipline, nurses are able to visit a rural community, set up a travelling vaccination clinic, take a headcount of people needing vaccination and then place an order to have that quantity of vaccine shots delivered by drone. The vaccine is stored in a climate-controlled facility prior to distribution by drone and packed with ice packs before flight to prevent a break in the cold chain. The vaccine is then flown to the clinic, where the nurses can administer it to those waiting. This ensures that those who have travelled to the clinic to get a vaccine on a particular day are vaccinated on schedule.

This distribution set-up is also an example of just-in-time logistics. With just-in-time logistics, based on the premise that materials or goods are received as they are needed, rather than days or weeks before, fewer resources are needed for onsite storage. Onsite storage is at a premium in many facilities in Africa, and in some cases, such as the travelling clinics described above, it is not an option. With just-in-time logistics coupled with an efficient ordering process and quick transportation, vaccines can be administered without risking excess waste due to storage limitations.

## 4.3 Drones and the COVID vaccine

With the proven use cases above, it is worth exploring whether drones can be used to deliver COVID-19 vaccines. As discussed in the case study, the low marginal cost of each drone flight shows it to be a scalable solution. While the challenge is, of course, the initial infrastructure and set-up, once that infrastructure is in place, nations will be able to repurpose this network for other uses, ranging from wider medical-supply delivery to aerial surveillance following a natural disaster. Stakeholder respondents in a survey indicated that it took them anywhere between six months and two years to get their drone programme operating. The principal timeline risk in implementing a new drone system, or significantly expanding a pilot programme, is the operator's ability to satisfy the myriad regulatory requirements associated with conducting such operations. As more drone operators seek to pilot and scale commercial programmes, there must be considerable focus on the aviation policy and regulatory frameworks necessary to allow such drone operations to provide services at scale.

Organizations that are already operating and have the necessary infrastructure in place would probably be candidates for using drones as a distribution network for COVID-19 vaccines. This is largely because the initial investment is typically the most burdensome, and the timeline of when the vaccines will be available to everyone is not concrete. However, organizations that wish to explore this

market may still have an opportunity to do so, as some civil aviation authorities have eased restrictions or sped up the process to get the necessary flight approvals. Strong, strategic partnerships with governments, the medical industry and others can also facilitate this. With these conditions in place, it may be possible to establish a programme in time for prompt distribution.

In addition, the cold-chain requirements for COVID-19 vaccines are a complicating factor. For one, using drone-based distribution to meet cold-chain challenges is successful only if the vaccine can remain usable while being kept at the temperature at which it will be flown. While drones can offer cooling technology (or in some cases ice packs), it first needs to be determined if that cooling technology can bring the temperature down to the necessary level to keep the vaccine stable. All COVID-19 vaccines require a cold chain of some sort, but some vaccines, including those currently in use, require an ultra-cold chain. Using drones for vaccine delivery may not be suitable for every COVID-19 vaccine, particularly those with ultra-cold-chain requirements.

Despite these challenges, drones offer an opportunity to effectively combat stock-outs when delivering COVID-19 vaccines. While drones cannot completely mitigate a nationwide shortage of vaccine doses, they can help minimize waste and ensure that available doses are efficiently distributed, particularly in hard-to-reach areas.

Rather than sending a fixed number of vaccine doses in a cooler, which can result in delivery of too many or too few doses, an order can be placed by a local healthcare worker to specify the exact number of doses needed. These doses can be delivered by drone and may be administered, without the risk of excess doses spoiling due to a mismatch between supply and demand. This can help combat potential vaccine shortages, since it helps ensure that as many people are vaccinated as possible, given the available supply. Additionally, since some COVID-19 vaccines require more than one dose to be fully effective, drones can help ensure that follow-up doses are distributed to those who have received their first dose when needed.

Perhaps the biggest promise in using drones at scale to deliver vaccines for COVID-19 or any other future event that necessitates reaching all citizens

quickly and efficiently is their ability to increase use of the healthcare system. By allowing all appropriate end points in the healthcare delivery system to be able to administer the vaccine, regardless of cold-chain infrastructure, reliable electricity, distance or quality of transportation infrastructure, drones can dramatically increase equitable access while reducing cost and wastage.

Though potential challenges exist with regard to drone use for the COVID-19 vaccine, there is enough merit in the solution for it to be explored in earnest. Particularly for the last mile of the supply chain, drones offer a scalable solution.<sup>28</sup> Drone technology is the future, and the current crisis may be an opportunity to advance operating drone programmes at scale to save lives.

## 4.4 Beyond the COVID vaccine

While the COVID-19 crisis can spur the adoption of drones by accelerating and expanding the distribution of a vaccine, it may also lay the groundwork for future drone programmes. The infrastructure and investment requirements to run a national vaccination campaign supported by drones is not negligible. However, these requirements are easily justified in the context of COVID-19. But once the vaccination campaign is complete, the drone infrastructure does not vanish, and neither do the other enabling conditions. By clearing the barriers to enable a vaccine delivery programme, it becomes far easier to establish other drone programmes,

expand existing ones or change the use cases than beginning from nothing. If a medical distribution network is set up to deliver a COVID-19 vaccine, this network can be reused to deliver additional medical goods, drop off other types of packages, gather aerial images to improve crop yields and much more. It would be a wasted opportunity simply to use drones to deliver a COVID-19 vaccine and then discard them afterwards. The future of drones lies in layering the different uses to save and improve lives on a national scale, and the COVID-19 crisis offers a compelling use worth exploring to catapult the industry into the next phase.



## 5

# Conclusion



Swoop Aero efforts in Malawi

Source: Swoop Aero

What became clear through the development of this report is that the drone ecosystem in Africa is maturing; it is no longer a regulatory playground, but a proof-of-concept for a successful drone delivery environment. Over the past six years, when drone programmes in Africa became a more significant presence, the ecosystem has gone from a few pioneering programmes in Rwanda and Malawi to almost a dozen programmes across the continent, including in Malawi, the DRC, Ghana, Nigeria, Senegal, Ethiopia, Sierra Leone and South Africa. Ideally, these will become long-term sustainable programmes, but only time will tell.

This technology saves lives. Early medical applications of drones have made that abundantly clear. In addition, it also saves costs and time. Drones can spur new investment and open the door to infrastructure investment, a skilled workforce, advanced aerial sensing applications and advanced air mobility.

Of course, drones do not solve every problem and are not suitable in every situation. Medical delivery drones, for example, are just one of many possible methods to transport goods from point A to B. However, in many hard-to-reach areas, drones may provide significant economic and time-reduction benefits in transporting life-saving supplies between two sites.

Using Deloitte's cost-benefit analysis model, we can better understand what moves the needle for success, both in terms of lives saved and cost savings, by performing a sensitivity analysis. Using this analysis, Deloitte found that the more critical input factors were a suitable business model, existing transportation costs and the size of the population served. Given the carefully considered business structure and the existing transportation challenges, the sensitivity analysis findings strengthen the case for large-scale, sustainable programmes. Governments and investors alike should take this

finding into consideration. Moving beyond the pilot programme model into large-scale applications not only saves lives but also increases operational efficiencies and realizes economies of scale.

In addition, Deloitte also explored enabling factors for rapid adoption. First, there must be an addressable need. As in the first case study, this problem could be high existing transportation costs and other accessibility challenges. Other enabling factors include a place for drones to fit into the supply chain, a regulatory environment that is not hostile to drone technology, and a community that embraces the technology and sees the value that it brings.

In terms of future use cases, drones are already playing a role in the fight against COVID-19. This scalable and contactless technology has been

proved by early use cases in Africa and is primed for widespread use. Within the “Great Reset” narrative, the crises of today can be opportunities for Fourth Industrial Revolution technologies<sup>29</sup> to be adopted at scale.

Most importantly, the drone industry needs to continue to evolve and progress. The continent of Africa is the worldwide leader in using drones for health applications. Over the years, it has served as a regulatory sandbox and proving ground for innovative technologies. The continent should continue to move forward by exploring unmanned traffic-management systems and identification methods, such as remote identification. This will both enable the widespread adoption of drone technology and support the continent’s standing as a leader in the ecosystem.

# Appendix A: A 10-prong consideration framework

Zipline's Delivery Efforts in Ghana

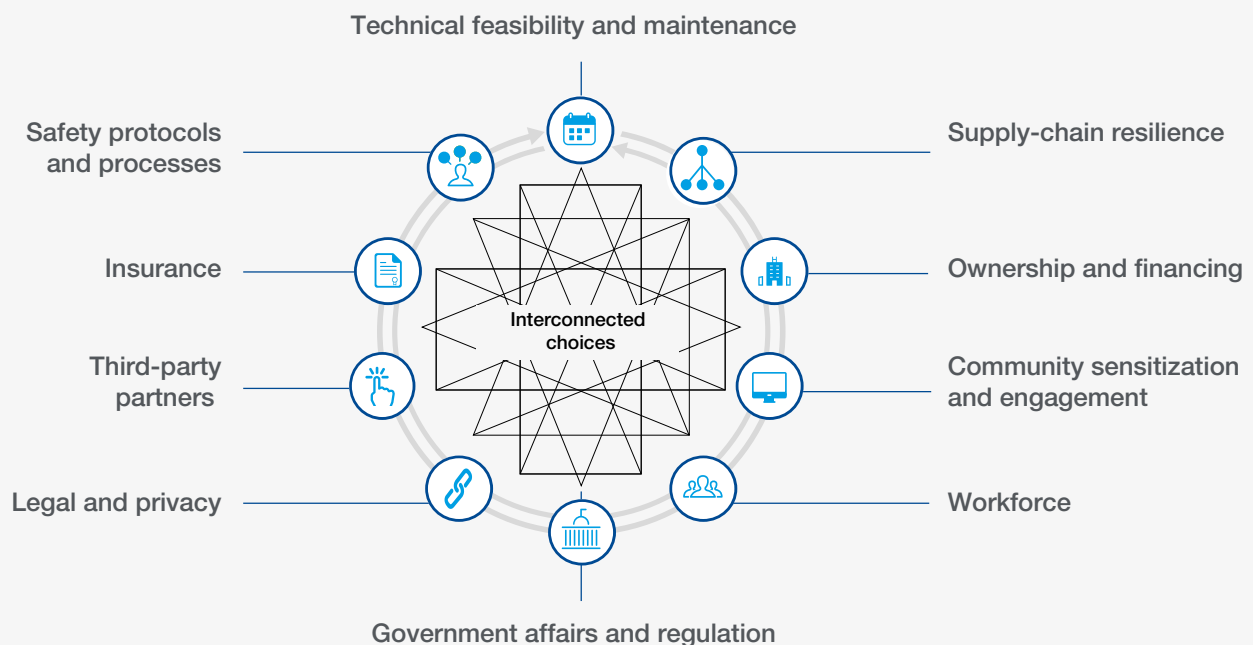
Source: Zipline



Successful drone programmes can be challenging to implement. Between unpredictable regulatory environments, financing hurdles and introducing a new technology into local communities, drone programme operators should enter the market carefully. Below are 10 key considerations to help enable a successful drone programme,

based on research and the accounts of leading industry stakeholders. These considerations are interconnected, as no one consideration is indicative of the success or failure of a drone programme. This appendix examines these considerations, illustrated by the experiences of our stakeholders.

FIGURE 5 Multidimensional considerations for drone operation in Africa



Source: Deloitte

## Technical feasibility and maintenance

When determining which drone is the right solution for a drone programme, organizations must consider capabilities and limitations.<sup>30</sup> The two primary categories for small payloads and most medical deliveries are fixed-wing and rotorcraft. A few drones combine multirotor with fixed-wing designs, referred to as eVTOL or hybrid drones, in order to provide a balance between range and easy take-off and landing. When determining which drone to use in a programme, a trade-off often occurs between selecting payload or range. In some cases, range may be limited by payload weight.

Important aircraft capability factors to consider include type, range, battery capacity, cargo capacity, maintenance requirements and their relationship to environmental factors, such as access to infrastructure and weather limitations. In addition, drone configurations vary and include fixed-wing, single-rotor, multiple-rotor and eVTOL fixed wing, with each type offering distinct advantages and disadvantages related to range, altitude, payload capacity and maintenance. Consideration of environmental conditions is also important. When considering a package-delivery use case, striking this balance is important in comparing multiple drones.<sup>31</sup> Of critical

importance is the presence of sufficient supporting infrastructure in a region.<sup>32</sup> Typically, communication between the ground station and any unmanned aircraft relies on sight radio networks, but some require a mobile phone network, which can be limited in African countries.<sup>33</sup> Weather conditions must also be considered as drones have wind limitations and limited ability to fly in poor weather. Addressing these technical challenges is vital to the development of a safe and effective programme.

Zipline illustrates the importance of considering many aspects of technical feasibility when starting a drone programme. To best meet its use case of transporting medical products from a few central locations to any health facility in Rwanda, Zipline designed a proprietary fixed-wing airframe. The fixed-wing airframe can travel 99 miles before recharging on average, enabling deliveries anywhere in the country. Additionally, Rwanda experiences significant rainfall, so it was crucial that Zipline factored this into its selection by designing a waterproof drone. The success of Zipline's drone programmes in Africa was facilitated by significant planning beforehand to ensure its programme was technically feasible.

## Supply-chain resilience

The part supply chain plays a significant factor in drone operations. To sustain reliable drone operations, it is important to set the foundation with a secure, cost-efficient supply chain, as an unreliable supply chain may lead to unreliable services in turn.<sup>34</sup>

Primary factors affecting the supply chain are the manufacturing and production of drone parts, and the impact that drones can have as part of other unrelated supply chains. Most drone part manufacturers are located outside of Africa, leading to high shipping costs to import necessary components to repair a drone. These, in turn, affect the cost-effective nature of the programme, as well as the reliability of the drone in a time-sensitive response scenario. When a new programme is established, developing a stable supply chain is one of the most important and cost-intensive endeavours.

One way to reduce both shipping costs from foreign vendors and lag times in receiving them would be to manufacture drones and any related parts within

the continent of Africa. Not only would domestic manufacturing dramatically reduce shipping costs and times, but the establishment of manufacturing plants throughout the continent could introduce technologically advanced, higher-paying jobs into the region. Rwanda, for one, has expressed interest in domestic manufacturing – the development of which could build upon the work already being undertaken to modernize Kigali as a “smart city” through a series of public-private partnerships, including with Carnegie Mellon University.<sup>35</sup>

To encourage learning between organizations in this space, VillageReach began the UAS for Payload Delivery Working Group (UPDWG).<sup>36</sup> The UPDWG is interested in the development, advancement and application of drones for use in public health and supply-chain systems. Its 322 members from more than 100 organizations share information, experiences and expertise, and are focused on collaborating rather than competing with each other.



## Ownership and financing

Business models and financing considerations are vital for determining the viability of a drone programme. Business models play an important role in predicting operating costs, and thus affecting the overall viability. A variety of business models are available. However, a few distinct ownership models are emerging in the drone ecosystem. The two most common ownership schemes are outright ownership and DDaaS. With outright ownership, the programme operates its own drones and is responsible for all aspects of the operation, from purchasing drones and supporting equipment to employment considerations such as obtaining its own qualified workforce, management and training, and other operational considerations, including insurance and liability concerns. Alternatively, DDaaS operates closer to a subscription model, where an organization seeking to use drones for its operations pays a flat fee per month and relies on the services of the drone company to carry out its mission, leaving the organization that manages the programme relatively hands-off in terms of daily flight activities. Generally, the industry is moving towards DDaaS and away from outright ownership, as DDaaS gives the subscriber more flexibility as technology evolves and missions change.

For financing, the first consideration is where to procure initial funding to operate a programme. Although not always the case, most drone programmes in Africa were initially established with the help of IDOs. With limited exceptions, the government is usually the customer rather than the financier, especially for programmes that have matured past the pilot phase. In addition to IDOs, sources for funding include private investment,

such as venture capital, user-fee models and partnerships with other companies. For these reasons, funding objectives should evolve as programmes grow. While pilot programmes may be initially supported by government funds, drone operators should eventually explore other sources of funding, including from the private sector or through co-financing (also known as blended financing) among various types of sources.<sup>37</sup>

Outright ownership and DDaaS are at two ends of the ownership spectrum, but in-between models can have characteristics of each. Other options include public-private partnerships (e.g. a model where the government does not own the drone asset but makes important managerial and operational decisions while the drone service provider executes the delivery), as well as a license model, such as the one Zipline has pursued in Japan with Toyota Tsusho. In 2021, VillageReach anticipates exploring the public-private partnership model for its operations in the DRC.

In the health industry, companies have used drones to deliver medical equipment, vaccines, blood and medicine to hard-to-reach areas. While there have been cases, such as in Ghana and Rwanda, where the government funded health-drone delivery pilot programmes for its citizens in the interest of public health, most African countries simply do not have the infrastructure, regulations or budget to subsidize drone delivery. As drone delivery scales across the continent, financial stakeholders must work together to ensure the viability of these life-saving programmes.

## Community sensitization and engagement

Public acceptance of any drone programme, especially where drone use is not widespread, relies on community sensitization. Community sensitization includes communicating, educating and demonstrating the benefits of drones to local communities and facilitating ways to keep them informed. In parts of Africa unfamiliar with drone programmes, new technologies may be feared, especially if they historically have been associated with privacy, nuisance and safety concerns. Regular, consistent engagement with the communities in which drones will operate is vital to addressing these concerns.<sup>38</sup>

In Malawi, UNICEF started with a small pilot programme for blood testing. Successes from this programme demonstrated to the local community the value of using drones for humanitarian purposes, which increased public acceptance. As a

result, UNICEF has today expanded its humanitarian drone programmes to include other medical-supply transport applications, and surveillance to determine areas vulnerable to flooding. In Malawi, the government encourages all operators to develop programmes involving communities from the beginning so that they are aware of the benefits of drones from planning to project implementation. A vital element of UNICEF's success stemmed from articulating to local communities that they were not tracking individuals, explaining instead the purposes of the information that they were collecting by drone. They outlined clear guidelines for data-use policies and always asked permission before taking any pictures, explaining what the images were used for. Once communities can see the benefit of drones, they often become comfortable with the use of such technology.

## Workforce

Workforce requirements are intricately linked to those of technical feasibility. Operating a drone programme successfully requires a workforce with a pool of specialized skill sets for the various specific positions, such as pilots and support staff. Specifically, pilots must have both practical experience and the proper licensing to operate these vehicles. Non-governmental organization (NGO)-led workforce development has been successful in building a domestic workforce for drone programmes deployed in African countries. This, in turn, not only provides aid in terms of the direct benefits the drones provide but also helps build a high-technology workforce in the countries in which the drones are operating.

Operated by UNICEF in partnership with Virginia Tech, ADDA was established to raise a new generation of drone professionals.<sup>39</sup> Through its experience of operating these programmes, UNICEF realized that these highly specialized employees were difficult to find. They could find students and recent graduates with related experience, such as in geographic information systems, but such people lacked the proper certification necessary to pilot the drone. ADDA

helps close the knowledge gap, ensuring a pool of professionals with comprehensive operational knowledge. However, qualifications alone are insufficient; practical experience is also required to ensure competency. ADDA enables the growth of a professionally trained workforce to support these programmes as they expand and new use cases emerge.

Across Ghana and Rwanda, Zipline employs hundreds of African engineers, pharmacists and skilled flight technicians. It has established a “Zipline Academy” at one of its Rwandan distribution centres for the purpose of scaling onboarding of new hires from across Africa.

WeRobotics strengthens and promotes local experts through “Flying Labs” across Africa (and worldwide). Rather than bringing in outside workforce and management, the Flying Labs model works to enable local leadership and ownership in the application of emerging technologies, connecting local experts to new opportunities and creating a cohort among the various Flying Labs where different teams can learn from each other.

## Government affairs and regulation

Government affairs and regulation define the scope and scale of drone company operations in each country. Depending on levels of regulation, drone use may be much easier – or much more difficult. As a result, examining the existing regulation is an early and necessary step that must be taken prior to planning or implementing any drone use.<sup>40</sup>

Encouraging government regulations can boost drone programme success.<sup>41</sup> In Rwanda, heavy government involvement has enabled a massive amount of progress to be made regarding the transport of medical samples and items throughout the country.<sup>42</sup> In 2016, the Rwandan government commissioned Zipline to pilot and develop the first commercial operation of drones in Africa for the purposes of delivering transfusion blood and other medical items across the country. The pilot has been successful, with around 150 shipments per day being delivered by its drone distribution centre. Now at scale, Zipline has reached its goal

of having “11 million citizens within a 30-minute delivery zone of essential medical products”.<sup>43</sup>

Another notable example of a government encouraging implementation of drones is in Malawi, which established and implemented a government-sponsored drone corridor to test and certify emerging technologies. Many drone companies and operators have used this drone corridor to test their technologies in a real-world environment and obtain certifications. Malawi has also been forward-leaning regarding government guidelines and developing drone regulations that are most suitable for its environment, as it examined other African countries’ policies before developing its own.

For countries working on their first set of drone regulations, ICAO has published materials providing model drone regulation and humanitarian operations guidance where countrywide regulations are lacking.<sup>44</sup>

## Legal and privacy

In addition to trespassing discussions, data privacy has emerged as one of the biggest concerns about drone use, particularly for surveillance applications, as people are worried that drones are recording them. Given this concern, the use of drones for imagery capture presents numerous challenges in terms of capturing, storing and publishing data.

For companies entering the market, drone operators should acquaint themselves fully with

national data protection laws for the country in which they operate to ensure compliance. It will be the drone operator's responsibility to prepare and document what measures have been taken for each task. For example, when Zipline was establishing its operations, it made the decision not to place any cameras on its drones. This holds true for Swoop Aero and Wingcopter, as well, unless cameras are specifically requested for imagery work.

## Third-party partners

Strong partnerships are a cornerstone for successful drone programmes. For a programme to be successfully implemented in Africa, it is crucial to involve local actors. Very few organizations have developed their own capacity or capability to operate drones completely independently. Third-party partners that have access to specialized information and knowledge of precedent and how technologies are viewed in the area are valuable to any government or company looking to grow into this market. For such reasons, many organizations choose to work with DDaaS service providers or in partnership with other communities to deploy and use drones, especially for health and humanitarian efforts.

One notable example of an African drone programme that relied heavily on third-party partners is the Malawi health sector examining the use of bidirectional drone transport, where supplies were both delivered to and from picked up from regional health facilities, rather than only being delivered. Beginning in 2016, multiple demonstration projects were completed over several years to determine the feasibility of bidirectional drone transport in Malawi. Over the course of these projects, the programme was able to demonstrate the integration of drones into the

health system across four districts in Malawi, while involving third-party partners, including UNICEF Malawi, VillageReach, USAID GHSC-PSM, the Malawi Department of Civil Aviation, the MOH and other Malawi stakeholders.<sup>45</sup>

The support from UNICEF and VillageReach helped the Malawi Department of Civil Aviation strengthen the regulators' institutional capacity, resulting in the development of an Aeronautical Information Circular on drones and drafting drone regulations.<sup>46</sup> This increased the government's awareness and capacity to promote the use of drones for humanitarian purposes throughout the country, and highlighted how the involvement of third-party partners can bring huge benefits to a government that is considering or interested in using drones in its country.

Zipline's strategic operational partnership with Toyota Tsusho Corporation in Japan will provide the first look at a scaled third-party implementation agreement and could become a model to emulate across Africa if drone technology companies can attract suitable operational partners capable of operating the considerable infrastructure needed to run a fully integrated drone delivery service.

## Insurance

Obtaining proper insurance is another essential component of entering the drone market in Africa. Choosing comprehensive and appropriate insurance policies is critical to ensuring that drone operations are protected. The challenge that arises when selecting the correct plan is that, while insurance is necessary, the recommended coverage is not well established or universally accepted across different countries.

As a universal policy, two main types of recommended coverage should be obtained. Hull insurance covers damage that occurs to the drone (e.g. if the drone crashes, the insurer will pay for either repair or full replacement if the damage is extensive), while liability insurance covers damage to third-party property and injury to other people. There are several types of liabilities to consider, including public (covering the impact on third parties) or employer/general (covering operators and associated staff).<sup>47</sup>

When trying to comply with insurance requirements, drone companies face large risks and associated costs. Companies have expressed that insurance is one of their most expensive costs – and that the decision-making process to determine policies was complex. Each insurance policy needed represents additional fixed costs for the company, so accounting for the various coverage types adds up quickly. Given the vague guidelines on drone insurance standards in most African countries,

drone companies also face financial and legal risks from insufficient insurance coverage.<sup>48</sup> Not all insurance policies are accepted universally throughout the continent, so it is important to consider all countries into which the operation may expand when planning for a scalable and long-term operation. However, regardless of a specific country's law, drone owners must protect the device from damage and safeguard against damage to others.

## Safety

Aviation safety is a foundational element of flight operations ingrained in every person, process and procedure as well as throughout the culture of professional aviation organizations. Drones as a subset of the industry have unique safety considerations. As a relatively new industry, the entire drone ecosystem must embrace its role in being responsible stewards as the number of flights conducted and the use cases performed grows. As the industry expands the capability to rapidly transport essential cargo such as blood, organs and tissue faster and further than ever before, and to people who previously did not have access to the benefits of healthcare delivery, every stakeholder must be constantly aware of the risks and hazards associated with flights over land and communities.

Malawi emerged as a leader by ensuring that safety was of the utmost importance in its Malawi drone corridor. The corridor provided companies with a designated place to begin operations and demonstrate capabilities in a safe and controlled setting, while also giving them the space and structure to prove to the government and ecosystem that their operations met a threshold of safety standards. By keeping standards high and providing this controlled setting, Malawi attracted market entrants and became a launchpad for growing as it expanded to new markets and other countries.



# Appendix B: Additional use cases



Source: Wingcopter

While this paper focused on the medical use case for drones in Africa, four other key use cases for consideration are detailed below.

## Aerial dispersion

Aerial dispersion is the distribution of a substance, usually a pesticide, over a large area of land, typically where a crop is growing. In a joint effort with Spanish drone manufacturer Embention, the Ethiopian government, the UN's Food and Agriculture Organization and the International Atomic

Energy Agency (IAEA), the Drones Against Tsetse programme is using drones to introduce sterilized tsetse flies to Ethiopia in the hope that the fly population numbers will decrease the following year, slowing the proliferation of African trypanosomiasis.<sup>49</sup>

## Aerial surveillance

Drones offer a cost-effective solution for continuous aerial surveillance that can extend beyond the boundaries of manned operations. Drones, coupled with advanced cameras, sensors and software, including an autonomous remote-sensing capability, offer a powerful solution to a wide array of challenges, such as aid in response to natural disasters like flooding, landslides and wildfires by giving first responders insight into a perilous situation as it develops.<sup>50</sup> For example, drones fitted with incident response sensors can help firefighters manage the spread of wildfires and assess the risk to surrounding areas, a perspective difficult to obtain using manned aircraft.

As part of the Air Shepherd programme, the Lindbergh Foundation, a non-profit organization focused on bold solutions to help balance technology and the environment, is using UAS for surveillance to combat poaching in South Africa.<sup>51</sup> By deploying drones that include a global positioning system (GPS) navigation system along with daylight and infrared cameras, park guards can pinpoint the location of poachers, offering a level of coverage not possible without an aerial view.

## Remote sensing

In addition to continuous surveillance, UAS fixed with advanced sensors and cameras serve as a powerful tool to enable remote inspections and imaging. In Malawi, UNICEF used UAS to obtain an aerial view of a region to identify areas in which increased sanitation efforts were needed to help prevent the spread of cholera.<sup>52</sup> According to

stakeholders from WeRobotics, remote-sensing continues to be one of the most proven use cases for drones in Africa and the most utilized drone activity for many of the independent Flying Labs on the continent.

## Heavy-lift cargo delivery

Large drones for cargo delivery are being tested. Although unique challenges are associated with heavy-lift applications, including limited battery capacity and safety and regulatory challenges, it remains an emerging use case for both commercial and humanitarian applications. Companies such as Elroy Air are exploring the

use of heavy-lift drones in Africa for middle-mile delivery, as they can derive efficiencies in moving larger cargo and greater quantities of goods, while also addressing the logistical challenges the region faces. In 2019, the World Food Programme began exploring the use of heavy-lift drones to deliver food and other supplies in Africa.<sup>53</sup>

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