DRONES DOING GOOD ALLIANCE

DDG ALLIANCE

NOVEMBER 2019

AUTHORS

TENDAI PASIPANODYA
MARISKA VAN GAALEN
PAOLA ZISMAN
HANS PETER THAMM

WHEN TO USE DRONES

Understanding when and under what conditions it makes sense to use drones to deliver critical healthcare products

Supported by the Business Partnership Fund

THIS REPORT WAS MADE POSSIBLE THROUGH
THE GENEROUS SUPPORT OF THE FOLLOWING
DDG ALLIANCE PARTNERS

CONTRIBUTORS:

Airbus
ZOE BEATTIE
REYMOUND YAW BUCKMAN
ALFRED LIEF
HARINI KULATUNGA
MADHUSUDHAN PADMANABAN
GUIDO SCHWARTZ

LifeBank
AISHA ABIOLA
ABRAHAM EKELE
TEMIE GIWA-TUBOSUN
SODIQ OLOKO
IFEOLUWA OLOKODE

Merck
MUNYA CHIVASA
HERVE KUBWIMANA

CONTACT: TENDAI PASIPANODYA
AT T.PASIPANODYA@ENDEVA.ORG.

DRONES
DOING
GOOD
ALLIANCE

SPECIAL THANKS

THE DDG ALLIANCE WOULD LIKE TO THANK:

THE BUSINESS PARTNERSHIP SUPPORT FUND OF THE UK GOVERNMENT FOR THEIR SUPPORT WITH THIS PROJECT AND CO-FUNDING CONTRIBUTION.

THE INFORMATION NETWORK AND SECURITY AGENCY (INSA) OF THE ETHIOPIAN GOVERNMENT FOR THEIR EXCEPTIONAL SUPPORT WITH THIS PROJECT AND THEIR FIELD OPERATIONS IN ETHIOPIA.

DRONES DOING GOOD ALLIANCE

CONTENTS

BACKGROUND 6
- ABOUT THE POC 6
- WHY IS IT IMPORTANT? 6
- METHODOLOGY 7
- OUR SYSTEMS CHANGE APPROACH 8

ABOUT THE USE CASE 9
- CRITICAL HEALTHCARE PRODUCTS 9
- HOW PRODUCTS GET TO POINT OF NEED 10
- ABOUT LIFEBANK'S OPERATIONS 10
- LOCATION A: AFAR STATE, ETHIOPIA 11
- LOCATION B: KADUNA STATE, NIGERIA 13

DRONES AS PART OF THE SOLUTION 14
- WHY DRONES? 14
- DRONE SELECTION 16

FINDINGS: WHEN TO USE DRONES 18
- SIX KEY CONSIDERATIONS 18
- BUSINESS-CASE FACTORS FOR LOCAL OPERATORS 19
- THE BUSINESS CASE TODAY 23
- NEAR-FUTURE SCENARIO 24
- THE FAR-FUTURE SCENARIO 25

RECOMMENDATIONS 27

OUTLOOK 29

DDG ALLIANCE

The Drones Doing Good (DDG) Alliance seeks to promote the smart, efficient and sustainable use of drones for the achievement of the UN Sustainable Development Goals (SDGs). We apply a systems-change approach to our work, support the localisation of technology and bring together a diverse group of partners in order to achieve the objectives of the Alliance.

AIRBUS BizLab Aerospace Accelerator

Airbus BizLab is a Global Aerospace Accelerator that transforms early-stage ideas into businesses in a hybrid model, combining external startups and internal innovation projects on the same platform.

endeva

Endeva is a systems-change facilitator with the mission to make the global economic transformation inclusive. We tackle today's development challenges by nurturing the businesses of the future. We support our partners to become future-fit and curate systems change in order to achieve the SDGs at scale.

lifebank

LifeBank is a Nigerian healthcare and technology logistics startup that applies innovation to the business of saving lives. LifeBank implements location-based optimised delivery with the best mode of transport for the job.

MERCK

Merck Accelerator selects, supports and partners with startups operating in healthcare, life sciences, performance materials, and other fields such as biosensing & interfaces, clean meat and liquid biopsy.

Dr. Thamm of Geo-Technic has 15 years of experience in operating successful UAS in different countries in Africa for resource management, mapping, agriculture and forestry, fighting erosion and environmental degradation.

BACKGROUND

ABOUT THE PROJECT

Today, it is clear that drones can play a vital role in delivering critical healthcare products. However, it is less clear when drones should be used in preference to other available mobility options, such as motorbikes, trucks or boats, in terms of maximising impact, saving the most lives and ensuring value for money for governments, hospitals and end clients in low- and middle-income countries.

This project set out to understand in which **cases** and under what conditions it **makes sense to deliver critical medical products with an unmanned aerial vehicle (UAV), a device commonly referred to as a drone.** The DDG Alliance set out to answer this question by conducting a practical proof of concept (POC) based on field research in Ethiopia and Nigeria and test flights in Ethiopia.

In January 2018, the JSI Research & Training Institute released a white paper entitled "What should you deliver by unmanned aerial systems?"[1] The white paper provided a highly valuable starting point for our efforts to answer our research question. However, the information in it is based on desktop research and theoretical considerations. Accordingly, the paper calls for more research based on actual cases implemented in practice. This is where this report adds value. It builds on the JSI white paper and adds considerations and recommendations based on the implementation of our POC.

WHY IS THIS INITIATIVE IMPORTANT?

Specifically, this POC focused on how we can enable local businesses in the critical health logistics sector to integrate drones into their operations. In the last few years, various groups have tested operations in which they have delivered healthcare products with drones. Most of these activities have been focused on a technological proof of concept. We extend that to include the business case.

Moreover, we focus specifically on working together to enable an African technology and health-logistics startup to expand their operations to include the option of drones. It is our conviction that the African drone market will need strong African players to thrive, and to produce sustainable business models that are able to solve local challenges.

1. JSI Research & Training Institute, 2018. 'What should you deliver by unmanned aerial systems? The role of geography, product and UAS type in prioritising UAS deliveries.'

METHODOLOGY

We carried out the following steps in order to answer our research question.

- **Use-case analysis**

We began by conducting research to improve our understanding of the need for critical healthcare products in Nigeria, in part by investigating LifeBank's model as a healthcare operator in the region in greater depth. Based on this understanding, we developed the criteria for the drone we would select for the field operations.

- **Drone selection process**

We surveyed the drone market to see which drones would meet our requirements. We had a long list of 15 companies, which we reduced to a short list of six models. Finally, the top three drone manufacturers were invited for tests in Germany.

The devices on our shortlist included the Germandrones' UAV Songbrid, Wingcopter's UAV 178 Heavy Lift and Vertical Technologies' UAV Delta Quad. Thirteen different categories of tests, including flight tests, were conducted at the Airbus Drone Centre. Through this process, we learned about the strengths and weaknesses of the drones on the market at that time, and selected the Wincopter 178 HL drone as the most suitable drone for our POC.

- **Drone licensing paperwork**

In parallel, administrative procedures were initiated by LifeBank in Nigeria to prepare the terrain for the POC. However, despite ongoing support from the aviation authorities in Nigeria for the project, security agencies have stalled the process of importing the drones into the country. Facing such regulatory constraints, we looked for alternative locations with similar needs for critical healthcare products, but where the permission to import and fly the drone might be more forthcoming. Ethiopia proved to be a suitable alternative location. The Ethiopian national-security agency, INSA, welcomed and facilitated the POC process with exceptional speed and efficiency.

- **Preparation and implementation of the POC**

After studying the use case and market need in Ethiopia, the POC research and beyond visual line of sight flights were successfully carried out in the Oromia region, in central Ethiopia. Additional field research on the use case was also conducted in the Afar region.

- **Consolidation of findings**

These activities ground and give credibility to the findings presented in this report.Through this practical and implementation-oriented process, the DDG Alliance experienced firsthand the complexity of setting up drone operations for critical healthcare products and of identifying suitable cases for drone operations. The key learnings have been consolidated into this publication.

OUR SYSTEMS-CHANGE APPROACH

Applying a systems-change approach

When considering the question of when to use drones, there are a number of potentially relevant factors. These considerations can make the use case more or less viable for a drone operator. The illustration below shows which types of stakeholders play a role.

The DDG Alliance applied a systems-change approach to this project, beginning by looking at the drones' ecosystem. We started by seeking to understand the motivations of the various actors, and identified which players would be critical to ensuring that drones would be used smartly and effectively in health deliveries in Africa.

It was clear that working with just a single actor would result in limited impact. For this reason, we assembled our "winning coalition" of partners that would be able not only to achieve the ambitions of the POC, but also to play an important role in scaling impact and enabling the commercial viability of drone deliveries.

The value of a systems-change approach was clear. A similar approach will thus continue to be applied in the pilot phase.

ABOUT THE USE CASE

CRITICAL HEALTHCARE PRODUCTS

Like their counterparts in many other low- and middle -income countries, healthcare systems in Nigeria and Ethiopia face significant challenges with regard to ensuring that blood, oxygen, vaccines and other essential medical supplies arrive where they are needed in the right condition and at the right time. The recent JSI publication entitled "What should you deliver by UAS" (JSI, 2018) identified five types of healthcare products that are suitable for delivery by drone. These include:

- Safe blood for transfusion.
- Routine vaccines.
- Long-tail products (products entailing small quantities and unpredictable demands).
- Programme and essential medicines (stockout response).
- Diagnostic specimens.

For our project, the DDG Alliance focused on testing the concept delivering blood, vaccines and samples. Blood and vaccines require an unbroken cold chain throughout the logistical process. We worked with the dimensions and weight typically used by blood supplies as a proxy. Vaccine and lab-sample deliveries do not have standard weight and dimensions but can fit within the parameters needed for blood.

A bag of blood that holds a pint is 473ml (<0.5 kg) and 105×105 mm (+/- 5 mm). The experiences gained through LifeBank's existing operations show that facilities order an average of two pints of blood per emergency.

BLOOD

According to the available evidence, about 26,000 women and 17,500 children die each year in Nigeria due to [2] a lack of blood at the point of need. It is estimated that over 34% of maternal deaths in sub-Saharan Africa are caused by postpartum haemorrhage[3] (PPH). PPH is defined as blood loss of 500ml or more within 24 hours after birth. Once bleeding has started, death can occur within two hours. In Ethiopia, PPH is one of the leadings causes of maternal mortality, along with preeclampsia/ eclampsia.
The shortage of blood at rural health facilities is a prominent barrier to the management of PPH in the country. [4]

VACCINES

Over the past five years, immunisation coverage in sub-Saharan Africa has stagnated at 72%, exposing populations to vaccine-preventable diseases and outbreaks.
Nearly 31 million children under five suffer from vaccine-preventable diseases.
Every year, more than 500,000 of these children die due to a lack of access to the vaccines they need.[5] Over 200,000 children in Nigeria die each year each year from vaccine-preventable disease.[6]
In Ethiopia, the rate of coverage of all basic vaccinations is highest in Addis Ababa (83%) and lowest in the Afar region (20%).[7]

SAMPLES

Early detection through collection of sample specimens is crucial in mitigating the effect of disease outbreaks where fast reaction time is of the essence. Cholera outbreaks were reported in several sub-Saharan countries in 2019, including the north-east region of Nigeria and several regions in Ethiopia.[8] Health centres in remote areas often lack disease surveillance facilities with linked diagnostic laboratories, and thus lack capacity to activate a rapid-response team for outbreaks. There is currently a missing link with regard to quickly diagnosing, tracking and pinpointing the origin of disease outbreaks in order to contain them.[9]

OXYTOCIN

According to the WHO, most PPH-related deaths could be avoided by the proper and timely administration of prophylactic uterotonics. Prophylactic uterotonics are substances used to induce contraction and increase uterine muscle tone during the third stage of labour – that is, the period between the delivery of the baby and the delivery of the placenta.[10] The WHO's first choice of such prophylactic uterotonics is Oxytocin.[11] However, Oxytocin is heat sensitive and requires transportation and storage at temperatures of between 2°C and 8°C.[12] In low-resource settings where the temperature cannot be guaranteed, the quality and effectiveness of available Oxytocin may be compromised.[13]

2. Unicef, 'Nigeria, Maternal and child health', retrieved 19 December 2017 from: https://www.unicef.org/nigeria/children_1926.html
3. USAID. 2016.Misoprostol Policy and Scale-Up for the Prevention of Postpartum Hemorrhage
4. WHO. 2015, Understanding Barriers and Facilitators to Implementation of Maternal Health Guidelines in Ethiopia
5. WHO, 2019, Experts caution against stagnation of immunization coverage in Africa
6. WHO, 'Child survival factsheets, Immunizations, WHO Immunization schedule Nigeria', http://www.childsurvivalnetwork.info/uploads/3/4/7/7/34772087/immunizations.pdf

HOW PRODUCTS GET TO THE POINT OF NEED

The logistics process followed by LifeBank is a 4Ds approach to critical healthcare logistics. LifeBank provides blood banks and oxygen suppliers with an inventory-management application where they input their **data**. This data is analysed and made available to hospitals on **discovery** platforms. LifeBank then deploys on the mobility solutions best suited for the specific hospital's geographical areas, for instance with motorbikes, boats or light trucks to ensure timely and high-quality **delivery**.

Additionally, LifeBank provides a platform for voluntary blood donors to book blood-donation appointments at the blood banks closest to them, enabling blood banks to receive these donors effectively.

Drone deliveries can be easily integrated into LifeBank's logistics process, as shown below. Drones would be an additional delivery option and complement the existing mobility options of motorbikes, trucks and boats.

Hospital searches for, discovers and orders blood on Lifebanks Plus App for smartphones, USSD App for basic phones or call our 24/7 call center to place an order.

Medical dispatch rider is notified with order details.

LifeBank rider picks up blood from blood bank and transports it in cold-chain boxes that follow WHO's blood-transfusion safety standards.

Blood is delivered to the hospital in the right condition, in under 45 mins.

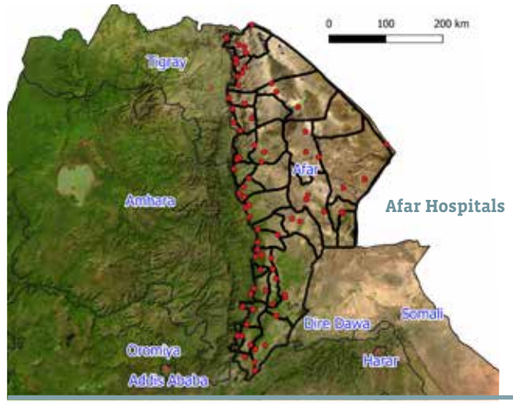
ABOUT LIFEBANK

LifeBank is a company in Nigeria that currently delivers time-sensitive, life-saving products via motorbike and boat in Lagos and Abuja. Their core delivery product is blood, but the company expanded its services to include emergency medical oxygen in 2018. Beyond the delivery of these essential medical products, LifeBank offers a full-spectrum solution that addresses the availability, discoverability, safety and affordability of these products.

LifeBank implements optimised technology and location-based delivery services to receive, match and dispatch orders for critical healthcare products. As LifeBank's delivery fleet expands to include more mobility tools, they will select the best mode of transport for the job, that is, the mode that will deliver the product at the best price-speed ratio.

7. UNICEF, 2019, 'Mini Demographic and Health Survey 2019'
8. WHO, 2019, weekly bulletin on outbreaks and other emergencies
9. Nature 2019 'How Africa can quell the next disease outbreaks'
10.http://www.who.int/reproductivehealth/publications/tranexamic-acid-pph-treatment/en
11. https://extranet.who.int/rhl/es/node/150966
12. https://gh.bmj.com/content/4/2/e001466
13. https://apps.who.int/iris/handle/10665/255550

LOCATION A: AFAR STATE, ETHIOPIA



Location
Northeastern Ethiopia coordinates:
11° 48' 59.99" N
41° 24' 59.99" E

Size [14]
72,000 km²

Climate type [15]
Desert and arid climate type, characterised by limited and unreliable rainfall.

Population in state [16]
1.5 million

CHALLENGES

- **Weather and climate**
  The region is a lowland area below sea level where temperatures routinely reach 48°C, making it one of the hottest places on earth.[15]

- **Low nomadic population density**
  Afar is a sparsely populated region with a population density of 7 inhabitants per km². The pastoral population herds livestock over vast distances.[17]

- **Absorption capacity**
  Health centres at the community level do not have the technical capabilities, storage capacities or skills to carry out critical healthcare services such as blood transfusions.

OPPORTUNITIES

- **Poor road infrastructure**
  This makes journeys arduous and long in the remote Afar region. Many areas are inaccessible by vehicle. This presents an opportunity to add value through drone-based delivery.

- **The tiered healthcare system in Ethiopia**
  This brings healthcare to the community level through extension healthcare workers.

The Ministry of health is working on expanding blood transfusion services at the level of Health Centers across the country. Health outposts do not have laboratory capabilities and while they are capable of collecting samples, transportation challenges and the absence of an established samples logistics network prevents health outposts from offering sample collection services to patients. Instead, patients must travel to health centers or hospitals with laboratory services. Patients must travel to a lab themselves.

14. World Bank, 2013. 'The Use of Random Geographic Cluster Sampling to Survey Pastoralists'
15. Climate Data. https://en.climate-data.org/africa/ethiopia/afar-1504/
16. UNICEF,2016. 'Afar Regional State 2007/08 – 2015/16 : Budget Brief.
17. FAO, 2016. 'Country Profile-Ethiopia

BUILDING ON ETHIOPIA'S HEALTH STRUCTURE NETWORK

3

serve 3.5 – 5 million people

Tertiary level
healthcare includes "specialised hospitals". They serve as referral centres for general hospitals.

2

serve 1 – 1.5 million people

Secondary level
includes "general hospitals". These hospitals act as referral centres for primary hospitals and training centres for health officers, nurses and emergency surgeons.

1

Primary level healthcare includes three subunits:

1 Primary hospitals provide emergency surgical services and are referral centres to HCs.

serve 60,000 – 100,000 people

2 Health centres (HCs) provide preventive and curative services and are referral points and practical training institutions for health extension workers.

serve 15,000 – 25,000 people

3 Health posts (HPs) are found at the village level.

serve 3,000 – 5,000 people

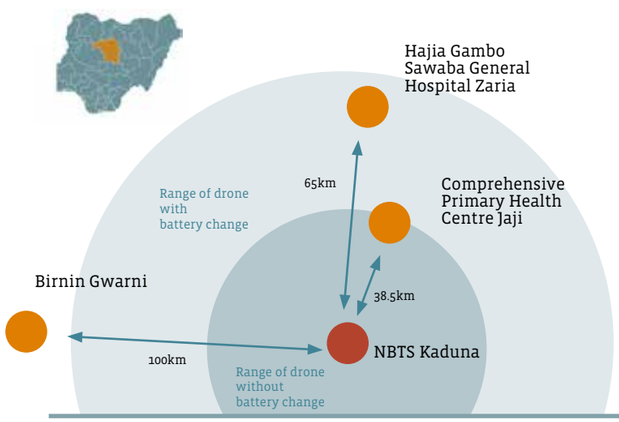
As in many rural areas in Africa, giving birth presents significant challenges for women in Afar.[18] While some women are able to go to a hospital before they give birth, thus ensuring proximity to care in the case of postpartum haemorrhage, the associated cost and complexity mean that many women give birth at home. Unfortunately, once a woman starts bleeding, she typically has only two hours to survive. Increasing the availability of blood at health centres will help reduce the distance women must travel in order to get care.

The prevalence of female genital mutilation (FGM) is high in Ethiopia among women aged 15-49 years (65%). This rate reaches 91% in the Afar region.[19] FGM has been shown to increase the risk of postpartum haemorrhage for women with type III FGM, which is the most severe form of FGM.[20]

picture: Barbara May Foundation

18. UNICEF, 2019, 'Mini Demographic and Health Survey 2019'
19. UNICEF, 2019. 'Community in Afar join forces to end FGM'
20. Adama Hospital Medical College, 2017. Factors Associated with Female Genital Mutilation among Women

LOCATION B: KADUNA STATE, NIGERIA



Location
Northern Nigeria
coordinates: 10°20'N 7°45'E

Size [21]
46,053 km2. It is 1.75 times the size of Rwanda, and is Nigeria's fourth-largest state.

Climate type [22]
Sudan Savannah type, characterised by tall grass and scattered short trees and shrubs.

Population in state [23]
8.2 million

CHALLENGES

- **Regulation**
  The security agencies in Nigeria slowed the process of gaining permission to carry out a POC focusing on drone usage in Kaduna.

- **Rainfall patterns**
  Kaduna is characterised by a rainy season starting in March and ending in November with maximum rainfall in August. Average rainfall is 1280mm and humidity ranges between 20% and 90%. The rainfall intensity in the wet season is quite high. Wind speed is mostly lower than 28km/h i.e. less than 8m/s.[24]

These two locations present different challenges and opportunities for the use of drones to deliver critical healthcare products. However, both locations feature a need for quick, safe and reliable transport in areas defined by hard-to-travel distances.
Drones might represent a viable option for life-saving services.

OPPORTUNITIES

- **Blood usage**
  Unlike in Ethiopia, blood use in Nigeria is not restricted to hospitals. Comprehensive primary care centres, which serve rural areas, offer obstetric and gynaecological services such as childbirth and minor surgeries, all of which often require blood. Unfortunately, such health facilities have limited blood-banking and screening capabilities, and thus often resort to the use of less thoroughly screened blood obtained from non-voluntary blood donors. Drones present an opportunity to transport blood from better-equipped blood-banking and screening facilities like the National Blood Transfusion Service (NBTS) in Kaduna.

- **Connectivity**
  The rate of second-generation (2G) mobile network coverage in Nigeria was 99.4% in 2016 (according to data from theglobaleconomy.com). However, 3G and 4G coverage rates are lower, with LTE available only in towns.[25]

21. Kaduna state population estimates for 2016 was 8,252,366 according to the National Bureau of Statistics, retrieved on 14 August, 2018 from: http://nigerianstat.gov.ng/elibrary.
22. Encyclopedia Britannica, retrieved on July 3rd 2018 from: https://www.britannica.com/science/Koppen-climate-classification
23. World meteorological organisation for the period 1961-1990.
24. Meteoblue - based on 30 years of hourly weather simulation
25. The Global Economy, retrieved on 14 August from: https://www.theglobaleconomy.com/Nigeria/Mobile_network_coverage/.

DRONES AS PART OF THE SOLUTION

WHY DRONES?

THE OPPORTUNITY THAT DRONES OFFER FOR CRITICAL HEALTHCARE PRODUCTS

Across Africa, millions of people die each year because hospitals are unable to obtain blood, oxygen, vaccines and other essential medical supplies at the right time and in the right condition. Poor and non-existent road networks are a critical logistical challenge in most African countries. According to the World Bank, sub-Saharan Africa is the only region in the world where road density has declined in the past two decades.[26]

The associated cost is substantial and includes the millions of lives lost annually by people, clinics and hospitals being unable to access critical healthcare products and services as they are needed, the thousands of accidents caused by pothole-riddled roads; and the countless economic opportunities that are impossible to seize without a safe, reliable, timely way to transport goods and services.

Drones have significant potential to improve the availability of health products in hard-to-reach locations. A major benefit of drones is their ability to fly over difficult terrain and improve the speed of delivery. Given previously mentioned challenges faced by many public health supply chains, drones may offer a reliable last-mile delivery system for selected scenarios. These include emergency or just-in-time deliveries of life-saving medicines or safe blood for transfusions in remote areas.

The drone-enabled delivery of critical healthcare products in Africa is in its early stages, although increasing activity is starting to take place. First-mover companies such as Zipline are being accompanied by an increasing number of actors. In 2018, UNICEF opened up a test corridor in Malawi where companies are allowed to fly test missions. Additional operations were facilitated in Sierra Leone in November.

WHY WE CHOSE TO USE A VTOL DEVICE

Our project aimed to extend the scope of services beyond long-range delivery to include pick-up of medical products. Layering use cases in this way holds the potential to truly revolutionise healthcare logistics through the use of drones in rural and remote areas. Drones with vertical take-off and landing (VTOL) capabilities also offer the advantage of flexibility in operations by avoiding the need for large and complex take-off and landing facilities. Instead of simply dropping the payload with a parachute, VTOL drones guarantee a smooth and safe delivery. Once selected, the landing sites require little preparation beyond spreading a tarp and pegging it to the ground.

For this reason, the DDG alliance focused its selection process on VTOL drones that fit the use case for the delivery and pick-up of healthcare products and samples.

We were aware that limiting the scope of investigation solely to VTOL drones could detrimentally impact some elements of the business case in the short term. For example, high cost of the VTOL systems could represent an accessibility barrier, or the shorter range of VTOL devices relative to fixed-wing aircraft could leave some locations inaccessible. However, since the technology is expected to advance rapidly in the coming years, the team believes that the potential benefits are high enough to offset these disadvantages.

26. The World Bank (2015). Why we need to close the infrastructure gap in Sub-Saharan Africa. Retrieved 21 December 2017 from: http://www.worldbank.org/en/region/afr/publication/why-we-need-to-close-the-infrastructure-gap-in-sub-saharan-africa

DIFFERENT TYPES OF DRONES

The table below provides an overview of the main types of drone categories, along with their advantages and disadvantages.

	ADVANTAGES	DISADVANTAGES
FIXED WING 	▸ longer flight distance ▸ have the ability to carry more weight	▸ no vertical take-off or landing ▸ requires a long runway ▸ requires complex landing infrastructure
MULTIROTOR  [27]	▸ vertical take-off/landing ▸ easy manoeuvering	▸ limited flying time and shorter travel distances
HYBRID 	▸ offers advantages of both fixed-wing and multirotor models ▸ vertical take-off/landing ▸ longer travel distance ▸ possibility to collect items from drop-off site ▸ minimal landing site preparation necessary	▸ generally less far in development, more nascent technology
ROTOR WING 	▸ heavy payload capacity ▸ ability to hover vertically in the air	▸ limited flight distance ▸ harder to fly ▸ expensive due to higher complexity and maintenance needs

27. Microdrones https://www.microdrones.com

DRONE SELECTION: WHICH DRONE WE SELECTED AND WHY

SELECTION PROCESS

The drone-selection process was divided into two steps:

1. A requirements analysis resulting in a shortlist of preselected drones
2. A test of the shortlisted drones in Germany, first at the manufacturers' company sites and afterwards at the Airbus Drone Centre.

A detailed account of this process is documented in the DDG project's Drone Selection Brief. In addition, a technical report is available upon request.

REQUIREMENTS

Based on the LifeBank use case, the project team established a set of 31 requirements covering the drone device itself, the specified operational activities/mission, logistics details, and relevant regulations. The table below summarises the drone-related requirements. As previously mentioned, the most prominent requirement was that the drone selected possess VTOL capacities, thus enabling the collection of diagnostic samples and other products.

REQUIREMENTS

TAKE-OFF & LANDING	Vertical take-off and landing, automatic on command.
PAYLOAD	Min. 2kg-3kg, 1.5kg net payload.
RANGE	Min. 30km one way, 60km return without battery charge at health facility.
MAX WINDSPEED	Should be able to operate up to 12 m/s.
TEMPERATURE	Must be able to handle temperatures of up to 40°C in shade.
HANDLING	One person must be able to handle aircraft alone.
ENGINES	Fully electric.
PROTECTION	Water resistant/dust proof.

PRE-SELECTION

Based on the project requirements and the specifications of the VTOL drones available on the market, the project team recommended selecting Wingcopter's Wingcopter 178 Heavy Lift, Germandrones' Songbird and Vertical Technologies' Delta Quad for further testing at the Airbus Drone Centre in Manching.

TESTING OBJECTIVES

One goal of the tests in Germany was to verify the specification-related information provided by manufacturers. Furthermore, the tests served the following objectives:

- To verify that the flight properties were correct.
- To verify that the flight paths were repeatable.
- To gain information on how best to design take-off and landing sites.
- To identify training needs for staff.
- To obtain an initial understanding of maintenance needs.
- To ascertain the selected drones' airworthiness.

DRONE TEST CRITERIA

- General handling (GH)
- Quality of frame (QF)
- Pre-flight check (FC)
- Flight planning (FP)
- Flight test (FT)
- Flight observation (FO)
- Emergency procedures (EP)
- Telecommunication (TC)
- General properties (GP)
- Maintenance (MA)
- Transport box (TB)
- Payload box (PB)
- System prices (SP)

Test criteria

To facilitate objective testing and comparability, the DDG team created a detailed criteria list for assessing all different aspects of the drone. This comprehensive list is of value beyond the scope of this project, because it enables a potential user to evaluate the drone's properties in an objective way, and facilitates fact-based decision-making when assessing safety features and identifying an appropriate drone. A full list of criteria is available upon request.

Final selection: Wingcopter 178 Heavy Lift

Among the drones tested, the Wingcopter 178 HL fulfilled all flight tests to the to the greatest degree. Furthermore, the company's communication was professional, and their customer-oriented service was highly appreciated. This is a very important factor for the DDG team considering that after-sales support will have the additional challenge of supporting operations on another continent. Thus, the Wingcopter 178 HL was selected as the most suitable commercial drone for the DDG Health project. An extensive technical report documents this process.[28]

ABOUT THE AIRBUS DRONE CENTER

The Airbus Drone Centre in Manching, Germany is a dedicated drone flight-test facility situated in the controlled airspace of the Ingolstadt/Manching Airport. The Drone Centre provides the opportunity to conduct flights in a controlled 2,500-metre flight zone, while supported by flight-test instrumentation and Airbus flight-test and airworthiness personnel.

28. Drone selection brief : https://www.dropbox.com/s/1kgotll34rrev0q/DDG_Drone%20selection%20brief_FINAL_E.pdf?dl=0
For the more technical and detailed documentation on the drone selection process please contact Tendai Pasipanodya: t.pasipanodya@endeva.org

FINDINGS: WHEN TO USE DRONES

SIX KEY CONSIDERATIONS

Due to administrative delays in Nigeria with regard to the licence to import drones, the location of the POC was moved to Ethiopia. Thanks to the strong support of the Ethiopian government's Information Network and Security Agency (INSA), a two-week campaign was successfully conducted in Ethiopia. During the campaign, we flew the drones beyond the visual line of sight, conducted field research and spoke to a range of local stakeholders. The following points consolidate the findings obtained though the proof-of-concept process, and provide the answer to our central question: In which cases and under what conditions does it make sense to deliver critical medical supplies with a drone.

CATEGORIES OF FACTORS

When considering when it makes sense to use drones, there are a number of factors that must be taken into account. These factors can be grouped into six categories, as illustrated below. The remainder of this chapter goes into more detail on these specific factors, with a focus on which factors could be changed to improve the business case for local operators.

6 KEY CONSIDERATIONS

DEMAND
Factors relating to the demand for critical healthcare products in the area to be served via drone.

DRONE SPECS
Factors relating to the specifications of the drone used to deliver critical healthcare products.

PRODUCT
Factors relating to the types and characteristics of the products to be delivered.

OPERATIONS
Factors relating to the operational aspects of drone-based delivery of critical healthcare products

INFRASTRUCTURE
Factors relating to the general infrastructure and geography of the area to be served via drone.

REGULATIONS
Factors relating to the regulations that form the legal context in which drones will be operated.

Business case factors for local operators.

Unlocking the business case – why changeable factors are the key

If we want to unlock the business case for the smart inclusion of drones in the delivery of essential medical products, it is critical to understand which of the factors influencing the use of drones are changeable, and which are set. Changeable factors are those which can be significantly influenced by any stakeholder in the drone ecosystem to positively increase the impact of using drones.

SET FACTORS

Set factors are those that **cannot be changed** in order to improve the business case for using drones in an impactful way. This does not mean they do not vary over time or place. For example, the density of healthcare facities in a given area may change over time. But stakeholders cannot change that density to make the business case more viable.

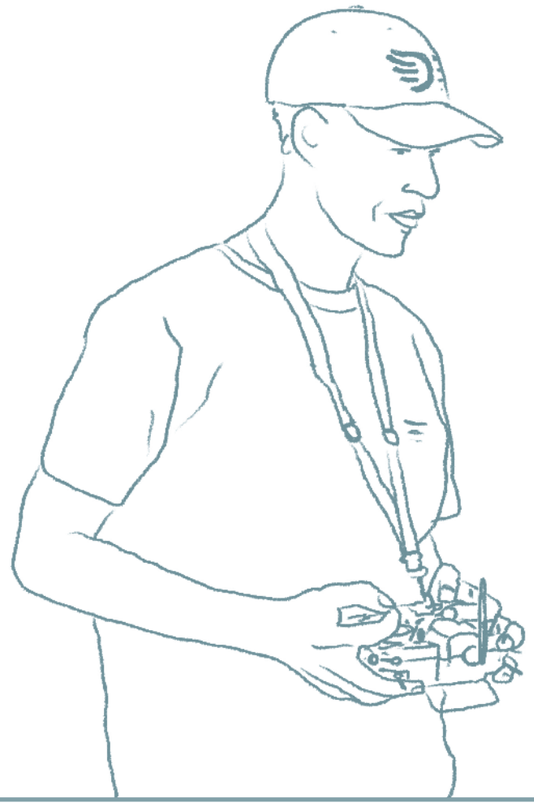
CHANGEABLE FACTORS

Changeable factors are those that **can be changed** in order to improve the business case for using drones in an impactful manner. Some factors, such as operational procedures, can be changed by the drone operator. Other factors can be changed by other ecosystem stakeholders. For example, governments can influence the cost and effort associated with obtaining a permit to use drones.

FACTOR	SET	ABOUT	MEASURE
DEMAND			
QUANTITY		The quantity of health facilities' demand for critical health products. This may fluctuate but is seen as a given.	Average quantity per month
VARIABILITY		The variability of health facilities' demand of the critical healthcare products. This too is given.	Standard deviation of monthly demand / monthly demand
STOCKOUTS		The frequency and extent of healthcare facilities' stockouts of demanded healthcare products.	% facilities with stockout; length and frequency of stockout at a facility
PRODUCT			
STORAGE		Shelf-life duration and required storage conditions.	Shelf life in days/ months/ years; description
FINANCIAL VALUE		The value of the product to be delivered.	USD per unit
WEIGHT / VOLUME		The weight and volume of the product to be delivered.	kgs per unit, litres per unit
INFRASTRUCTURE			
HEALTH FACILITY DENSITY		The density of health facilities that are within the drone's range and have the capability to use the delivered products.	No. of facilities per 10,000 square km
ACCESSIBILITY		The ease or difficulty with which a healthcare facility can be accessed. This is a given for the operator.	% of facilities inaccessible by road * % of year inaccessible by road
ROAD SURFACE QUALITY		The quality of road surfaces on way to health facility – for instance, smooth tarmac or a bumpy gravel road. Can be changed but is a given for operations.	Travel speed by road in km/hour
ROAD CIRCUITY		Travel distance by road to a health facility vs distance "as the crow flies".	Distance in km/ straight-line distance
CONNECTIVITY		Available 2G, 3G, and 4G connectivity in the area of operations. The GSM net can be supplied by setting up a reliable and inexpensive telecommunication net (e.g. 866 kHz).	% of area with each type of connectivity. USD for additional setup

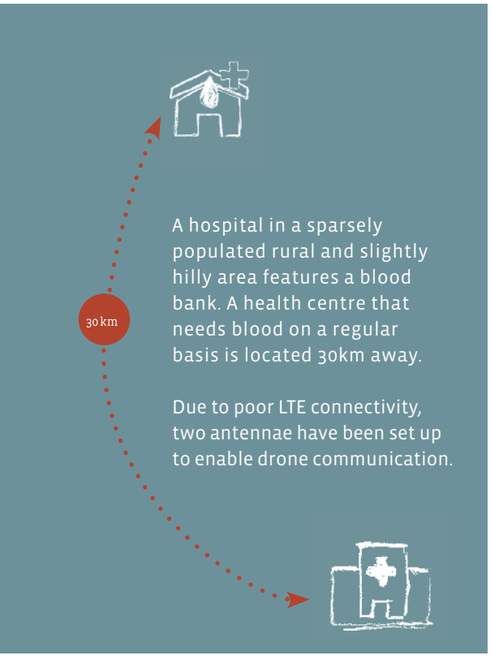
FACTOR	SET	ABOUT	MEASURE
DRONE SPECIFICATIONS			
PERFORMANCE		Drone performance, including its range, safety and ease of use. While given per drone, this is rapidly changing as the sector continues to innovate.	Maintenance, repairs and spare parts
TOTAL COST OF DRONE USE		The total cost of operations, which includes maintenance costs, product lifetime, etc.	USD per hour of operations
PAYLOAD		The maximum amount a drone can carry per trip. This is given per drone but can change as sector innovates.	Payload in kgs., payload in litres
MAINTENANCE, REPAIRS AND SPARE PARTS		The cost and ease of maintaining and repairing drones and batteries. This largely influences operations and depends on manufacturing base.	Average time and cost required to obtain, maintain and repair drone.
DEPRECIATION		The rate at which a drone loses its value over time. This largely depends on the lifetime of the drone.	% of initial cost of the drone
OPERATIONS			
POWER		The cost of the electricity used to charge the batteries of drones used in operations. This is given in an area.	Local price per kWh
TRAINING		The cost of training staff in the operation of drone-based delivery services. This depends on talent pools and procedures.	Cost per day * no of days
COLD-CHAIN BOX		The cost of the cold-chain box. This can be changed by collaborating with manufacturers of cold-chain solutions.	USD per unit
PILOT AND FLIGHT OPERATIONS STAFF		The cost of the pilot and other flight operation staff needed for drone operations. This can change depending on the local talent pool.	Salary per month

FACTOR	SET	ABOUT	MEASURE
REGULATIONS			
LICENSING		The time and money needed to obtain a licence to fly in a given area. This is changing as regulations are put in place.	Cost in USD, time in days / weeks to obtain a permit
INSURANCE		The total cost of insurance needed in order to operate drones for delivery in the given area.	Annual cost in USD
CUSTOMS		Cost and time needed to import drones and drone parts. This is influenced by how products are categorised by tax laws. Integration of drones in the general airspace. Need for an unmanned air traffic management (UTM) system.	Cost in USD and time in days to import products



THE BUSINESS CASE TODAY

To help illustrate the current business case, we present a fictitious but typical example below that is based on the practical lessons derived from the use cases for Nigeria and Ethiopia.



Transit results: how long does it take and how much does it cost?

Drone: The drone has a flying speed of 80km/h at relative wind speed. In this case, the total transit time required to go from the blood bank to the point of need is nearly 23 minutes. This includes 22min 30seconds flying time and 40 seconds for take-off and landing. A drone has the advantage of being able to fly the linear distance, while cars must follow roads. Assuming operations are running at a low scale of 1,000 flights annually, transit costs are estimated at €140 per round trip flight. Time calculations do not include the time involved with receiving the request, preparing the delivery package or any procedures at the destination. The time these procedures take is considered to be equivalent to those found in any other mode of transport.

Small truck: A small truck on a bad road with potholes that is only partially tarred travels at an average speed of 20km/h. Since a motorbike would have to travel along a road rather than the linear distance, we increased the distance to be travelled by a factor of 1.5 for a total distance of 45km, which would involve a total transit time of 2h 15 minutes. In certain circumstances, such as flooding or heavy rains, roads could become impassable and thus prevent critical healthcare product delivery. Per-trip transit costs for a small truck are €5.75. Monthly costs such as driver salary, fuel and maintenance account for some 66% of small truck operation costs.

Conclusion: Such a use case could present a use case for drone deliveries today. Other factors, such as a high density of health centres that use blood within a 30km radius or a high monthly average demand for blood at each health centre, could improve the business case.

SCENARIO TODAY

Time in minutes	Cost in EUR per delivery	Number of lives saved
23 min	€140	1 life saved and 10 samples can be collected

KEY LIMITATIONS TODAY

- Some 65% of transit costs for the drone are linked to the total cost of ownership, which includes drone and battery total costs as well maintenance, repair and spare parts costs.
- Initial set-up costs for operations and the costs of required learning and training in order to standardise operations are high. We estimate this to total about €700 per flight for the first 1,000 flights.
- An unfavourable regulatory environment for drone operations in many countries limits the use case.

POSSIBLE CHANGES TO FACTORS

CHANGING DRONE PERFORMANCE

At the time of the POC drone selection, the range of the best drone for the job was approximately 80 km one way with a 2kg payload. This range determines the number of health facilities that can be serviced from a specific blood bank. If the drone's range (for the same payload) were improved by 40kms, for example, this would increase the number of health facilities that can be serviced significantly. In addition, features that would improve drone ease of use (e.g. a simple go-home button), in combination with improved connectivity (e.g. through the inclusion of antennae) would reduce the number of pilots needed at the first point of departure from two to one, and further lower operation costs.

CHANGING THE LOCAL CAPACITY FOR DESIGN, BUILD AND MAINTENANCE

A substantial 65% of a drone's transit cost in the scenario for today derives from the total cost of drone ownership. Although the technology is developing rapidly, the best drone for the job is currently designed and built outside of Africa. As a result, certain aspects of maintenance require outside expertise and the importation of spare parts. This increases a drone's downtime and involves considerable costs associated with either sending the drone to the manufacturer or having a specialist fly in to carry out repairs. In this scenario, sending the drone to a manufacturer can result in a loss of days of flights which, in turn, results in less lives saved. Alternatively, flying an expert in for repairs increases total operation costs which, in turn, increases delivery costs. Having local expertise to assemble, repair and maintain the drones would therefore significantly increase the number of lives saved.

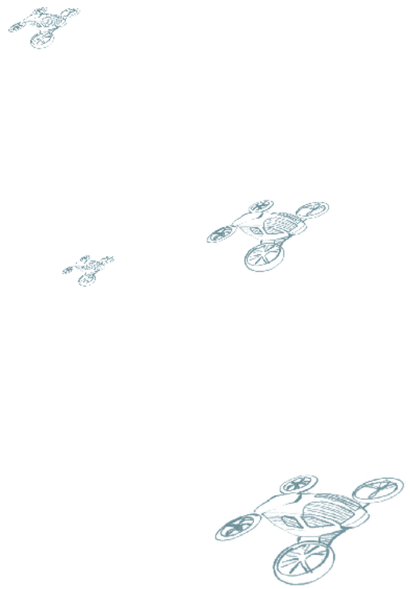
NEAR-FUTURE SCENARIO

Time in minutes	Cost in EUR per delivery	Number of lives saved
↓↓	↓↓	↑↑↑

THE FAR-FUTURE SCENARIO

Envisioning the far future by drawing on reasonable assumptions and current trends is a helpful exercise for organisations when contemplating alternative futures.[29] Imagining the future ties in well with a systems-change approach because it allows us to better consider how best to reconfigure a particular system so that its equilibrium is inline with our desired future.

Since envisioning the future at Endeva's ii2030 event[30] was the genesis of this proof-of-concept project, it was only fitting that the DDG Alliance once again reimagine the far future as a means of shaping the way forward. The illustration below depicts an optimistic "Wakanda" scenario for the delivery of critical health care products.



TRENDS

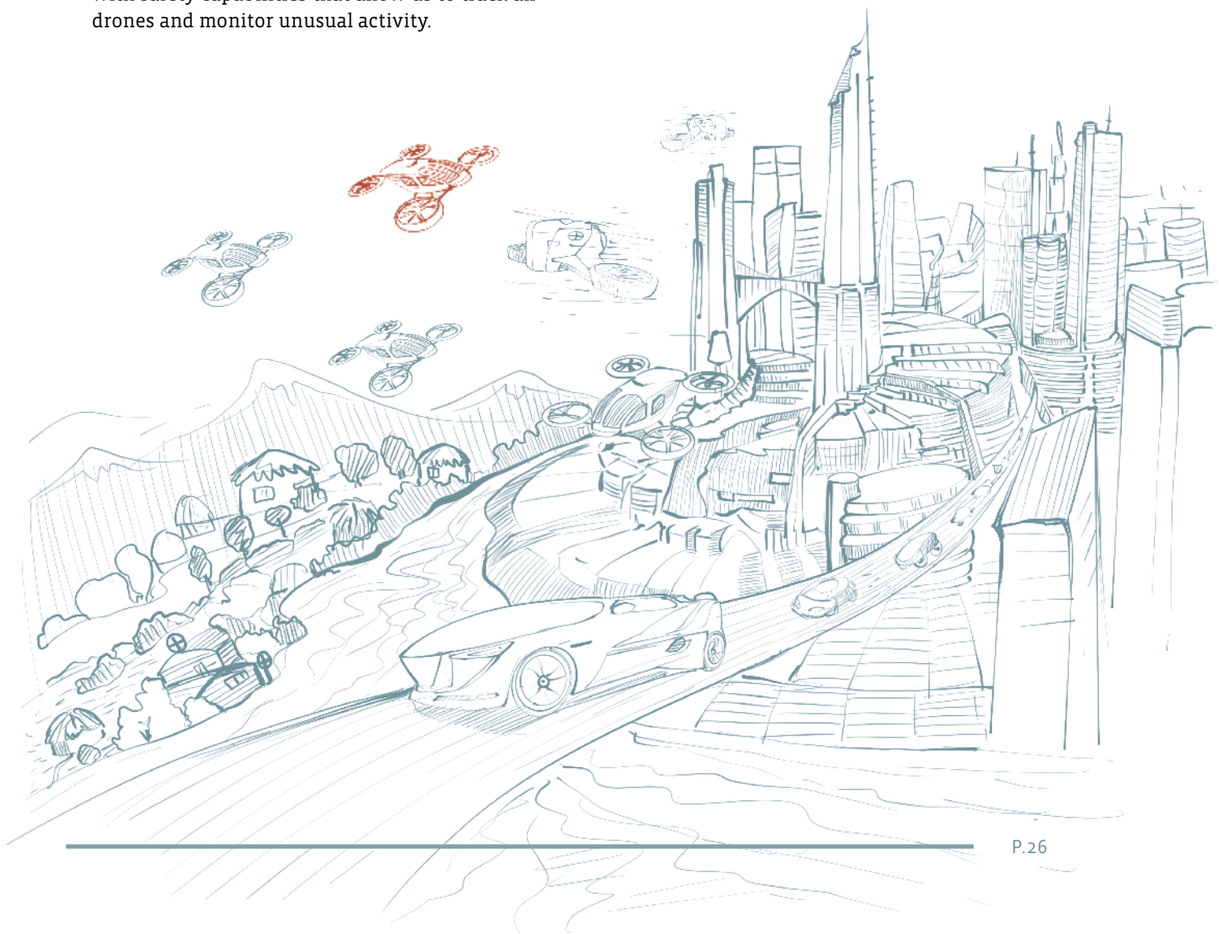
- Progress in efficient fuel-cell technology to boost power in drones
- Clean energy sources
- Artificial intelligence in healthcare
- Drone-enabled deliveries
- Advances in manned drone technology
- Improvements in ATM systems
- Retro-innovation around preventive medicine
- Clean energy

FUTURE SCENARIO

29. Accenture. https://www.accenture.com/_acnmedia/pdf-73/accenture-business-futures-interactive.pdf
30. https://www.ii2030.com/tracks/drones

FUTURE REALITIES

- **Widespread physical connectivity becomes a reality.** Today, widespread mobile phone connectivity is a reality. In tomorrow's world, widespread physical connectivity will be a reality.
- **Drones are widely used as a part of standard delivery services** with a 5kg payload drone that has a 250km radius being widely available at relatively low cost. Drones will be very reliable and easy to use for those without extensive experience with predictive health monitoring systems, fail-safe features and advanced emergency procedures.
- **Drone ambulance and flying physician services will reach most remote areas.** This will be enabled by commercially available manned drones with a payload of 200kg that are able to fly 2,500km.
- **Sophisticated air traffic management systems for manned and unmanned traffic.** Drone corridors with safety capabilities that allow us to track all drones and monitor unusual activity.
- **Increasingly sophisticated services at the primary healthcare level** that are supported by technologies such as remote diagnosis and robot-assisted minor surgery. This will be combined with a retro-innovation focus on preventive care.
- **Locally designed and manufactured drones** featuring smart, durable and nature-inspired design and perhaps produced by a 3D printer.
- **Increased availability of critical healthcare products** translates into a greater ability to meet blood demand through the separation of blood products and perhaps the creation of synthetic blood.
- **Clean energy used in all delivery by motorbike or motor vehicle**.



RECOMMENDATIONS

This section highlights the role ecosystem players can have in influencing changeable factors while enabling the smart, cost-effective, efficient and commercially viable use of drones for critical healthcare.

OPERATIONS

- **Assemble, manufacture and design drones locally**

Currently, the commercially available drones that fit the requirements of local operators in countries like Ethiopia and Nigeria are designed and manufactured abroad. Despite being the most technologically advanced options, drones are not optimised for local heat and humidity conditions. Localising design and manufacturing bears the potential to create products specifically made for local markets. Furthermore, local repairs and maintenance will significantly reduce the cost per flight. Localised design that is optimised for cost-efficient mass production can lower the price of a drone. Similarly, maintenance costs can be lowered by locally manufactured replacement parts and locally trained technicians.

- **Provide quality skills training**

Drone operators can only be as good as their staff. As this sector continues to grow, many new jobs will emerge that require a talent pool of people trained for specialised roles such as pilot technicians, air traffic controllers, and so on. This means that higher education institutions will play a critical role in training and educating this talent pool, ideally in collaboration with the private sector in order to ensure that the skills match the sector needs.

- **Provide an air traffic management system**

As more drones take to the air, UTM systems will become essential to ensuring safety in a context of several different operators. A UTM system, can meet the demands on national security and strengthen the acceptance of delivery services.

FUNDERS
GOVERNMENTS
DRONE MANUFACTURERS
CORPORATIONS
OPERATORS

DRONE SPECIFICATIONS

- **Increase drone safety and ease of use**

Increasing drone range or payload can significantly improve the business case, as would further improving drones' failure rate and ease of use.

- **Increase drone payload**

The amount of payload a drone can carry heavily influences local operators' business models, particularly when the required product is needed for an emergency and exceeds the current payload. Further innovation that enables larger payloads will propel these business models.

- **Reduce the total cost of ownership**

The total cost of operations will continue to fall as commercial drone markets develop. Increasing drone range with new technologies like fuel cells will strengthen business cases considerably. Having drones and spare parts manufactured specifically for local needs, having locally available technicians for repairs and maintenance, and being able to receive spare parts quickly will play a big part in strengthening the business case.

INFRASTRUCTURE

- **Set up cost-effective solutions to ensure connectivity**

Network companies can support the use of drones telecommunication by working to improve networks in rural areas. Drone operators can set up their own telecommunication.

REGULATIONS

- **Provide clarity on licensing**

The more clearly a country regulates and establishes the permission-to-operate procedures for drone operators, the more viable venturing into this field becomes for local businesses.
Regulators – including security agencies – should work hand-in-hand with operators to define sandboxes and create corridors where drone usage can be safely explored. Drone corridors allow stakeholders to test assumptions, collect data and improve on all aspects concerning drones, from regulation to manufacturing to operations. For example, the creation of the UNICEF Malawi drone corridor, which allows for beyond visual line of sight (BVLOS) testing in a 5,000 square kilometre area, has enabled stakeholders such as manufacturers to identify the changes needed to improve flight stability. The creation of drone corridors in African countries will foster innovation and collaboration in the drone sector while facilitating their safe integration into African airspace.

- **Provide transparency on customs procedures and costs**

Regulators can encourage a sector by making custom procedures clear and information about requirements readily available.

- **Facilitate policy dialogue to ensure the safe use of drones**

Given the sector's rapid development, governments are advised to do more to understand the needs of local companies with the potential to start local operations. This dialogue would also help prevent the misuse of drones.

OUTLOOK

As a rapidly developing sector, commercial drone technology has significant potential to accelerate the achievement of the United Nations' Sustainable Development Goals (SDGs). This will require the continued collaboration of ecosystem players across the board. The DDG Alliance is excited to be a part of these developments.

The DDG Alliance will continue to work in particular on enabling local companies in low- and middle-income countries to become pioneers in the use of drones for positive impact, whether in health, agriculture or other sectors that are important to achieving the SDGs.

We will do this by focusing on two areas:

Pilot follow-up to the POC:
We are currently looking for partners to follow up the POC with a multi-country pilot. This could include Ethiopia and Nigeria, among other countries.

Technology localisation:
Manufacturing in Africa specifically is needed to expand operations. This includes the local repair, maintenance, design and manufacturing of drones as well as increasing the talent pool of pilots and technicians.

WE LOOK FORWARD TO COLLABORATING WITH ANYONE INTERESTED IN ACHIEVING THESE GOALS.

DRONES
DOING
GOOD
ALLIANCE