DRONE SELECTION BRIEF

DRONES DOING GOOD HEALTH

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TABLE OF CONTENTS

Annexes are separate documents and can be supplied upon request.

BACKGROUND

This ecosystem scan has been developed to support a proof of concept (PoC) for the use of UAS (Unmanned Aerial Systems, also referred to as drones) to deliver critical healthcare products to economically marginalised groups in rural Nigeria. The project is being implemented by the Drones Doing Good (DDG) Alliance consisting of: Airbus, Endeva, Geo-technic, LifeBank and Merck KGaA. The initiative aims to understand in which cases and under what conditions it makes sense to use drones over alternative means of transport in such a use case.

The project works with LifeBank, a Nigerian healthcare and technology logistics start-up, initiating activities to increase their reach to at-risk populations far more rapidly than they could on their own. The project will identify which UAS would best suit LifeBank's use case and test a potential solution in Germany, at the Airbus specialist facility in Manching, and in Kaduna State in Nigeria. The costs and opportunities of using UAS for delivery will be compared with other transport options.

Since the face-to-face project kick-off in May 2018, the DDG team has held weekly meetings, held a face-to-face workshop on requirements for the PoC and conducted email and phone interviews with the UAV manufacturers of the drones considered to be within scope.

USE CASE

CRITICAL HEALTHCARE PRODUCTS

Like many other rural areas, the healthcare system in Kaduna faces significant challenges in finding blood, oxygen, vaccines and other essential medical supplies in the right condition and at the right time. The recent publication on "What you should deliver by UAS" (JSI, 2018) identified five types of health care products that can be suitable to deliver a) safe blood for transfusion, b) routine vaccines, c) long-tail products (small quantity, unpredictable demand products), d) program and essential medicines (stock out response) and e) diagnostic specimens.[6]

For this project, the project team considers testing the concept of operations for blood, vaccines and oxytocin. Further, because LifeBank is a health logistics company, they are particularly interested in the future possibility of collecting diagnostic samples at the drop off location.

All three products require an unbroken cold chain throughout the logistical process. The team will work with the dimensions and weight of blood as a proxy because vaccines, oxytocin and lab samples do not have standard weight and dimensions but can fit within the parameters needed for blood.

A bag of blood is 473ml (<o,5 kg) and 105 x 105mm (+/- 5mm) which is equivalent to circa one pint. On average, facilities order 2 pints of blood per emergency.

ABOUT LIFEBANK

LifeBank is a company in Nigeria that is currently delivering time sensitive, life saving products with motorbikes and small trucks in Lagos. Their key product is blood but they plan to expand to other products. LifeBank combines widespread low tech USSD codes with innovative high tech artificial intelligence (AI) to receive, match and dispatch orders for critical health products.

LifeBank implements location based optimised delivery with the best mode of transport for the job, i.e. the mode that will deliver the product at the best price-speed ratio. LifeBank believes that UAVs will be the fastest and most cost effective way to deliver life saving products to rural areas in the near future.

6. 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.'

LOCATION: KADUNA STATE

GEOGRAPHY

Kaduna state is located in northern Nigeria (coordinates: 10˚20'N 7˚45'E). Covering an area of 46,053 km2, it is 1.75 times the size of Rwanda and Nigeria's fourth largest state. According to the 2016 estimates of the National Bureau of Statistics, the state's population is 8,252,366.[1] The vegetation cover is Sudan Savannah type, characterised by tall grass and scattered short trees and shrubs.

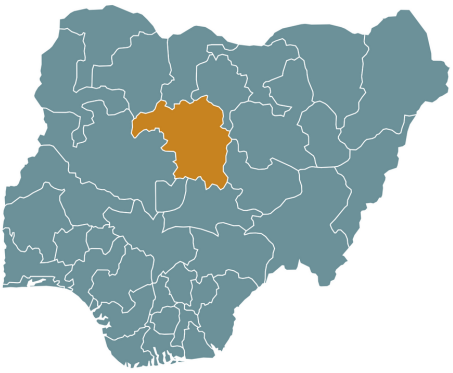


Figure 1. Map of Nigeria, Kaduna State

WEATHER & CLIMATE

The climate in Kaduna state is tropical, classified as Aw (winter dry season) in the Köppen-Geiger-Pohl climate classification.[2] The average maximum temperature varies between 35˚C in the dry season to 27˚C in the rainy season with the lowest average minimum temperature in December at 14.4˚C.[3]

Wind speed is mostly lower than 28km/h i.e. less than 8m/s. In the dry season in January and February there are some days with wind with up to 11m/s. Note that this wind speed can be higher 30m above ground because wind speed is measured 2m above ground and increases in higher altitudes following a logarithmic curve.

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. In the dry season from December to February there is nearly no rain, but even in the rainy season there are days without rain. Only few days have rainfall intensity higher than 10mm/day.[4]

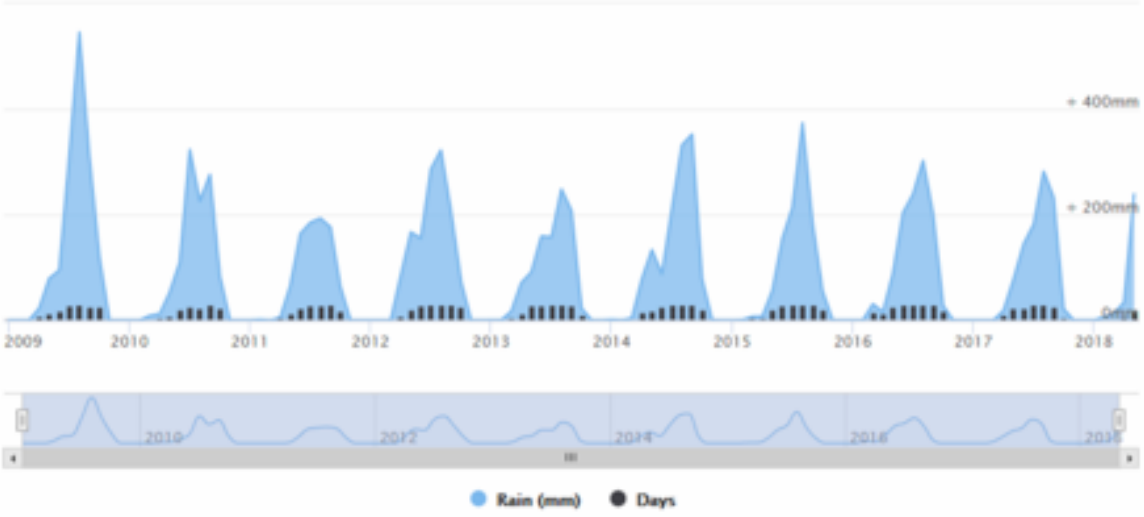


Figure 2. Rainfall distribution in Kaduna state 2009-2018. Source: worldweatheonline.com

1. 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.
2. Encyclopedia Britannica, retrieved on July 3rd 2018 from: https://www.britannica.com/science/Koppen-climate-classification
3. World meteorological organisation for the period 1961-1990.
4. Meteoblue - based on 30 years of hourly weather simulation

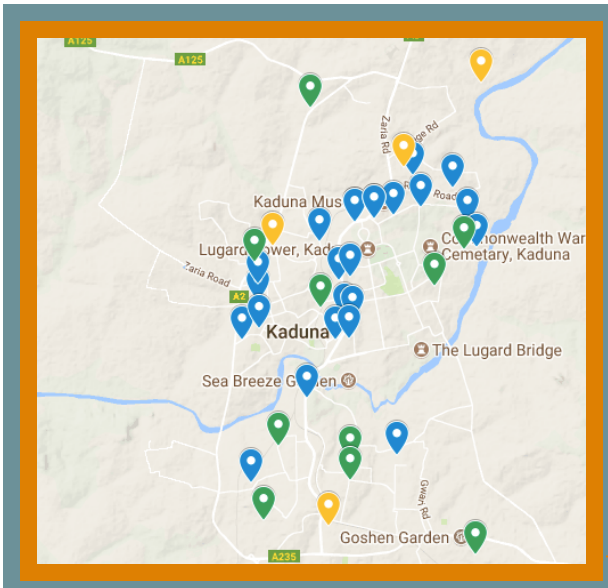


Figure 3. Distribution of Health Facilities in Kaduna City

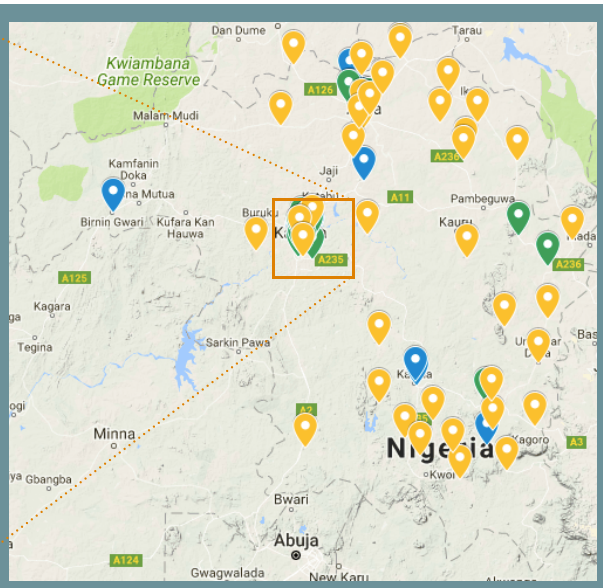


Figure 4. Distribution of Health Facilities in Kaduna State

Legend: Hospitals Clinics Government Primary Health Centres

CLIENT DENSITY: LOCATIONS

Kaduna city is the largest city of Kaduna state, with a population of 760,084 and a population density of 5,800/km². Currently, all five blood banks of Kaduna state are located in Kaduna city as well as 24 of the 35 hospitals. The 11 other hospitals are found in the towns of Zaria, Igabi, Kachia, Kafanchan, Birnin Gwari, and Hunkuyi. The spread of clinics shows a similar pattern, with of 17 of 10 located in Kaduna city, four in Zaria and the rest in rural areas. Furthermore, 40 primary government health centres (PGHC) have been identified in Kaduna State. Of these, 32 are located in rural areas, i.e. outside Kaduna city and other towns.

CLIENT DENSITY: DISTANCES

Taking Kaduna city as the central focal point, the closest hospital outside the city is approx. 44km away (as the crow flies) in Igabi. After that, the closest hospitals are approximately between 60 and 75km away in Zaria. The hospital farthest from Kaduna city is in Kafanchan at approx. 145km distance. The clinics that are outside Kaduna and Zaria lie between approx. 110 and 120km from Kaduna. There are two PGHCs within 30km range of Kaduna city and three within 30km range of Zaria. The PGHC farthest from Kaduna city is at 165km distance.

CONNECTIVITY

In order to know where the UAV is at any given time during operations, connectivity must be maintained. For close range, within visual line of sight (VLOS), the UAV sends command and control telemetry data through a direct radio link. However, for command and control beyond visual line of sight (BVLOS) the UAV must either be supported through specialised ground station equipment with antennae, or solutions must be found using existing mobile networks. Mobile network coverage (2G) in Nigeria was 99.4 per cent in 2016 (according to data from theglobaleconomy.com).[5] However, 3G and 4G coverage are less widespread with LTE only being available in towns.

5. The Global Economy, retrieved on 14 August from: https://www.theglobaleconomy.com/Nigeria/Mobile_network_coverage/. Mobile network coverage measures the percentage of inhabitants who are within range of a mobile cellular signal, irrespective of whether or not they are subscribers. This is calculated by dividing the number of inhabitants within range of a mobile cellular signal by the total population.

SCOPE: FOCUS ON VTOL

"MORE ADVANCES IN THIS TECHNOLOGY CAN BE EXPECTED IN THE COMING YEARS."

-DRONES IN HUMANITATIAN ACTION

Right now, proof of concept already exists for fixed wing and copter delivery of critical healthcare products. Zipline is operational in Rwanda while Matternet has permission to deliver in Switzerland. However, this project seeks to further extend the scope beyond long range delivery to include pick-up of medical products, thus layering use cases, with potential to truly revolutionise healthcare logistics with the use of UAVs in rural and remote areas,

That is why the DDG alliance focussed this ecosystem scan on VTOL UAVs that fit the use case for delivery and pick up of healthcare products and samples in Kaduna State, Nigeria.

The project team is aware that limiting scope to VTOLs only could detrimentally impact some elements of the business case in the short term, due, for example, to the relatively high cost of the VTOL systems, or to the lower range of VTOLs respective to fixed-wing. However, since the technology is expected to advance rapidly in the coming years,[7] the team believes that potential benefits are high enough to offset this impact, including the advantages of layering multiple use-cases through a return cargo capability, gaining flexibility in operations by avoiding the need for large take-off and landing facilities, as well as the learning value from a proof of concept that focuses on VTOL operations.

7. Swiss Foundation for Mine Action (FDS), 2016. 'Drones in Humanitarian Action.'

REQUIREMENTS

TAKEOFF & LANDING	Vertical takeoff and landing, automatic on command.
PAYLOAD	Min. 2kg-3kg, 1.5kg net payload.
RANGE	Min. 30km one way, 60 return without battery charge at health facility.
MAX WINDSPEED	Should able to operate up to 12 m/s.
TEMPERATURE	Up to 40˚C in shade.
HANDLING	One person handling.
ENGINES	Fully electric.
PROTECTION	Water resistant/dust proof.

Based on the use case of LifeBank in Kaduna state, the project team established a set of 31 requirements covering the UAV, operations/mission, logistics and regulations. The table above summarises the UAV related requirements. The most prominent requirement is that of a VTOL (vertical take-off and landing) UAV to enable the future scenario of collecting diagnostic samples. For the full list of requirements, please refer to Annex A.

To assess the business case, including the cost per hour of operations and the total cost of ownership of the UAVs, the project team will use the framework proposed in the White Paper "What you should deliver by UAS". [8]

COST OF OPERATIONS

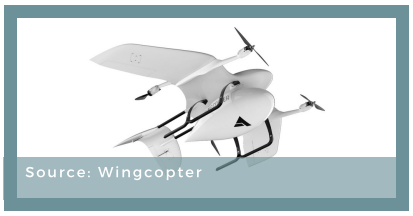
The White Paper "What you should deliver by UAS" proposes three dimensions: geography, UAS characteristics and product /demand, each with factors to consider such as the density of healthcare facilities and the quantity of product demand. Data related to the factors will be gathered over the course of the project.

6. 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.'

UAV SHORTLIST

MOST PROMISING UAVS FOR THIS USE CASE

The scan covered world wide extensive research on VTOL UAV manufacturers, For a full list of UAVs considered, please refer to Annex B.


Source: Wingcopter

WINGCOPTER

Company: Wingcopter
Location: Germany
Founding year: 2013


Source: www.germandrones.com

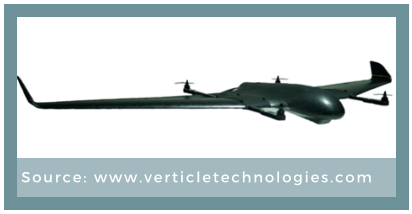
SONGBIRD

Company: Germandrones
Location: Germany
Founding year: 2016 (maiden flight Songbird 2014 by Aerolution)


Source: www.quantum-systems.com

TRON

Company: Quantum
Location: Germany
Founding year: 2015


Source: www.verticletechnologies.com

DELTA QUAD

Company: Vertical Technologies
Location: Netherlands
Founding year: 2016


Source: www.altiuas.com

ALTI

Company: Alti
Location: South Africa
Founding year: 2009

DECISION MATRIX

	WING-COPTER	SONG-BIRD	TRON	DELTA QUAD	ALTI
RANGE					
PAYLOAD					
TAKEOFF & LANDING					
WIND					
TEMP.					
HANDLING					
ENGINES					
PROTECT-ION					

	Requirement fulfilled
	Requirement partially fulfilled
	Requirement not fulfilled

This matrix shows how the identified UAVs were evaluated by the team against the project's requirements. It should be noted that this rating is based on specifications obtained from the manufacturers on request. These must still be verified in the testing phase. Specifically, the maximum wind speed can differ from what is indicated. For a full list of UAVs considered, please refer to Annex B.

PRE-SELECTION

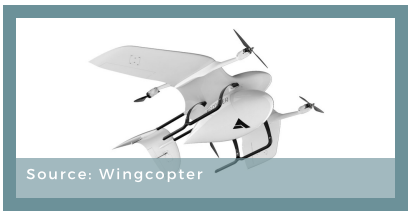
FOR TESTING AT THE AIRBUS DRONE CENTER

PRESELECTION AND PRE-TESTS

Based on the specifications of the five potential VTOL UAVs rated against the project requirements, the project team recommended selecting the Wingcopter 178 HL of Wingcopter, the Songbird of Germandrones and the Delta Quad of Vertical Technologies for further testing at the Airbus Drone Centre in Manching. Both the Songbird and the Wingcopter are manufactured from glass fibre and carbon fibre compound. The Delta Quad is made from foam and has a significantly lower price. The team decided to test the Delta Quad as well to compare its performance with the higher price range drones. The three UAVs were first tested at their company sites to check basic requirements.

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 is open to third parties and provides the opportunity of flying in a controlled environment of 2500-metre flight zone whilst supported by Flight Test Instrumentation and AIRBUS Flight Test and Airworthiness personnel.



Source: Wingcopter

WINGCOPTER

Company: Wingcopter
Location: Germany
Founding year: 2013

Source: www.germandrones.com

SONGBIRD

Company: Germandrones
Location: Germany
Founding year: 2016

Source: www.verticletechnologies.com

DELTA QUAD

Company: Vertical Technologies
Location: Netherlands
Founding year: 2016

TESTING

OBJECTIVES OF TESTING

Testing in Germany was conducted to verify manufacturer information on specifications as part of the process of selecting the right drone for the use case in NIgeria. Furthermore, the testing served the following objectives:

- To know that the flight properties are correct.
- To know that the flight paths are repeatable.
- To know how to design take-off and landing sites.
- To identify training needs for staff.
- To get an initial understanding of maintenance needs.

WHAT WE TESTED

Over the course of two days each in September 2018, the Songbird and Wingcopter were tested at the Airbus Drone Center in Manching. The Delta Quad was available at a later time and was tested near Berlin.

To facilitate objective testing and comparability, the DDG team created a detailed criteria list for assessing all different aspects of the UAV. This comprehensive list is of value beyond the scope of this project, because it enables a potential user to assess the properties in an objective way and helps to make a fact based decision to find the appropriate UAV as well as assess safety features. A full list of criteria is available in Annex C.

UAV TEST CRITERIA

- General handling (GH)
- Quality of the 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)

FINAL SELECTION

WHY WE CHOSE WINGCOPTER

"THE WINGCOPTER 178 HL IS SOLIDLY BUILT, FAST TO MOUNT, AND AUTOMATED TAKE-OFF AND LANDING ARE PRECISE."

The Wingcopter fulfilled all flight tests to satisfaction. It is solidly built, fast to mount and has the demanded range (take off, flying 30 km one way, automatic landing, changing payload, take off again, flying 30 km back and landing automatic). The automatic take off and landing were precise; the landing point was within a radius of 3 meters. The emergency tests worked correctly, the payload box is appropriate for our demand and spare part supply seems to be reliable.

Furthermore, the company communication and performance was professional, which is a very important factor for the DDG team considering that after sales support has the additional challenge of supporting operations in Nigeria.

To conclude, the tests show that the Wingcopter is currently the most suitable commercial UAV for the DDG Health project in Kaduna State, Nigeria.

DRONE SELECTION BRIEF

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).

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