MALAWI REMOTELY PILOTED AIRCRAFT (RPA) TOOLKIT

A Guideline for Drone Service Providers and Implementers in the Development, Humanitarian and Research Fields

Photo credit: Matternet/Messinis

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TABLE OF CONTENTS

CONTRIBUTORS *2*
ABBREVIATIONS AND ACRONYMS *3*

1 INTRODUCTION 5

2 REMOTELY PILOTED AIRCRAFTS (RPA) IN MALAWI 5

2.1 HISTORY OF RPAS IN MALAWI 6
2.2 KASUNGU HUMANITARIAN DRONE TESTING CORRIDOR 6

3 ADMINISTRATIVE AND OPERATIONAL REQUIREMENTS 7

3.1 DEPARTMENT OF CIVIL AVIATION 8
3.1.1 Corridor Testing Application 8
3.1.2 Outside Testing Corridor Flight Authorisations 9
3.2 MALAWI REVENUE AUTHORITY 11
3.2.1 General RPA Customs and Tax Guidelines 11
3.2.2 Temporary Importation 12
3.2.3 Permanent Importation 13
3.3 MALAWI TELECOMMUNICATION REGULATORY AUTHORITY 13
3.4 AFFILIATED GOVERNMENT INSTITUTIONS 14
3.5 NATIONAL RESEARCH AND ETHICS APPROVALS 14
3.5.1 Regular Approvals 14
3.5.2 Expedited Approvals 15
3.5.3 Student Approvals 15

4 WHO SHOULD YOU ENGAGE? 15

4.1 NATIONAL LEVEL 15
4.2 DISTRICT LEVEL 16
4.3 COMMUNITY LEVEL 16

4.3.1 GENERAL PUBLIC 16

5 OPERATIONAL CHECKLISTS 17

5.1 LOCATION CHECKLIST 18
5.2 PRE-FLIGHT CHECKLIST 18
5.3 TAKE OFF CHECKLIST 19
5.4 LANDING ZONE CHECKLIST 21

6 LEARNING FROM EXPERIENCE 22

6.1 MANAGEMENT OF STAKEHOLDER EXPECTATION 22
6.2 IMPORTING POLYMER LITHIUM BATTERIES 22
6.3 LOCAL ASSISTANCE 22
6.4 TESTING DURATION 22
6.5 ELECTRICITY 23
6.6 TRANSPORT 23
6.7 PARTS AND SUPPLIES 24
6.8 SOFTWARE 24
6.9 ALTITUDE AND WEATHER 24
6.10 RADIO FREQUENCY INTERFERENCE 24
6.11 MOBILE PHONE COVERAGE AND COMMUNICATION 25
6.12 INTERNET CONNECTIVITY 26
6.13 OPERATIONAL CAPACITIES 26
6.14 AGGRESSIVE BIRDS 27
6.15 PETROLEUM QUALITY 27

6.16 Infrastructure Locations and Topographical Maps 27
7 SUPPLEMENTARY INFORMATION 27
7.1 Emergency Standard Operating Procedures 27
7.2 Bare Minimum Pack 28
Table 1: Bare Minimum Item List 28
7.3 Travel Advice 28
7.3.1 General Safety *28*
7.3.2 Food Safety *28*
7.4 Frequently Asked Questions 29
7.5 Cost Estimates of RPA Activities 29
8 CONCLUSION 31
9 APPENDIX 32
9.1 Contact List 32
9.2 Online Corridor Registration 34
9.3 Cellphone Towers 34
9.4 Stakeholder Sensitisation Strategy 34
9.5 Example Emergency Standard Operating Procedure and Emergency Checklist 34

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ABBREVIATIONS AND ACRONYMS

ATC	Air Traffic Control
BVLOS	Beyond Visual Line of Sight
CRS	Catholic Relief Services
DCA	Department of Civil Aviation
DJI	Dà-Jiāng Innovations
ESCOM	Electricity Supply Commission of Malawi
ETA	Estimated Time of Arrival
GHSC-PSM	Global Health Supply Chain-Procurement and Supplies Management
GIZ	German Development Corporation
GPS	Global Positioning System
ICAO	International Civil Aviation Organisation
ICD	Import Custom Duty
LUANAR	Lilongwe University of Agriculture and Natural Resources
MACRA	Malawi Communications Regulatory Authority
MBTS	Malawi Blood Transfusion Service
MERA	Malawi Energy Regulatory Authority
MICT	Ministry of Information Communication and Technology
MOHP	Ministry of Health and Population
MOI	Ministry of Information
MOJ	Ministry of Justice
MRA	Malawi Revenue Authority
MZUNI	Mzuzu University
NCRSSH	National Committee on Research in Social Sciences and Humanities
NHSRC	National Health Science Research Committee
NOTAM	Notice to Airmen
PLB	Polymer Lithium Battery
PMPB	Pharmacy Medicines and Poisons Board
RF	Radio Frequency
RPA	Remotely Piloted Aircraft
RTH	Return to Home

TNM	Telecom Networks Malawi
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UMT	Unmanned Traffic
VAT	Value Added Tax
USAID	United States Agency for International Development
UPDWG	UAV Payload Delivery Working Group

1 INTRODUCTION

Unprecedented development and perforation of Remote Piloted Aircraft (RPA) technology in the public domain has created a need for information and guidelines to help guide safe and successful RPA operations globally. In Malawi, the Department of Civil Aviation (DCA) developed robust RPA Regulations through a consultative process, based on International Civil Aviation Organisation (ICAO) RPA Guidelines. However, as this is a new technology with expanding potential applications, users have often faced hurdles as well as contextual information gaps in moving to implementations. Recognising this challenge, Malawi RPA stakeholders teamed up to consolidate and share their range of experiences, opportunities, challenges and lessons encountered in implementing RPA operations to date.

The aim of this effort is to ensure safe and efficient future RPA operations, in Malawi, by providing crucial local information including contacts, required processes, general challenges, recommendations and general advice. While every environment is unique and technology is dynamic, Malawi RPA stakeholders recognise that collaborating to address common challenges not only benefits individual operations but also enhances the development of the local RPA potential and capabilities.

The Malawi RPAs Toolkit has six sections. The first section introduces the toolkit's objectives and outline. Section 2 provides an overview of history of RPA operations in Malawi. Section 3 outlines administrative and operational requirements for importing and operating RPAs in Malawi. Section 4 focuses on who and how to engage stakeholders in RPA operations. Section 5 is a generic RPA operations checklist. Section 6 delves into key lessons learned, so far, by various organisations, companies, operators, and individuals, and provides suggestions for smooth and safe RPA operations in Malawi. Section 7 covers any additional aspects to consider and includes sample tools for various RPA-related activities, followed by a conclusion. The Appendix contains a list of materials that may be useful for specific RPA use cases.

2 REMOTELY PILOTED AIRCRAFTS (RPA) IN MALAWI

Drones are known by different names in the English language, including Unmanned Aerial Vehicles (UAVs) and Unmanned Aircraft Systems (UAS). In the Malawi airspace, drones of different types and for different uses have been in existence for some time now. The Malawi Civil Aviation official nomenclature follows the ICAO standard for RPA. For this reason, this toolkit will maintain the Government of Malawi's official nomenclature.

2.1 History of RPAs in Malawi

The first use of government-approved RPAs in Malawi occurred in March, 2016, as part of UNICEF's study "*Feasibility and Cost-Analysis Study on Using Drones to Transport Laboratory Samples for Early Infant Diagnosis of HIV*".[1] Since then, RPAs have been used primarily for topographical mapping including forests, land boundaries, and water and sanitation points.[2]

In 2017, RPAs were used in Karonga and Salima to assess the extent of damage caused by flooding, paving the way for the inclusion of RPAs in the government's emergency response and preparedness strategy. RPAs were used again, in 2019, to assess the impact of devastating floods throughout the southern region of the country. The data acquired in both 2017 and 2019 are being used to develop flood preparedness models that will assist in ensuring the well-being of communities affected by recurrent floods.

Additionally, RPAs have been used for testing the transportation of medical commodities including blood, oxytocin, and essential medicines. These tests have been conducted by the Ministry of Health and Population (MOHP), VillageReach, Malawi Blood Transfusion Service (MBTS), and Pharmacy Medicines and Poisons Board (PMPB) study, and the Global Health Supply Chain-Procurement Supply and Management (GHSC-PSM) programme.

2.2 Kasungu Humanitarian Drone Testing Corridor

In 2017, the Government of Malawi and UNICEF launched the Humanitarian Drone Testing Corridor in Kasungu Municipality, 128 km from the capital city, Lilongwe. It has 40 km flight radius from the airstrip at Kasungu Airport with an overall diameter of 80 km. This first of its kind corridor opened the country's airspace to RPA companies, academic institutions, non-governmental organisations, and others to test RPA technologies, for various use cases, while also building local skills and entrepreneurship. Use cases have included collecting imagery of mosquito larvae for malaria vector control, crop surveillance and soil nutrition, monitoring infrastructure development, testing unmanned traffic management systems, and teaching Malawian students how to build RPAs.[3]

[1] Matternet implemented the RPA flight operations and VillageReach conducted the cost analysis
[2] Implementers include: Bunda College, Precision, COOPI, the Malawi Red Cross and UNICEF
[3] Implementers include: Lancaster University, University of Liverpool, Precision, GlobeHe, VillageReach, Vayu, Kyoto University, Virginia Tech State University, UAVAid, NextWing

Figure 1: Runway within the Humanitarian Drone Testing Corridor. Photo credit: UNICEF Malawi

3 ADMINISTRATIVE AND OPERATIONAL REQUIREMENTS

This section covers obligatory processes and activities that RPA operators and/or implementers must comply with in order to begin RPA operations, in Malawi. Authorisations and documentation from various government departments and agencies will be required at various stages. The following are the key government and international institutions to engage:

1) The Department of Civil Aviation provides flight authorisation for RPA operations including a flight operations, inspection and monitoring.
2) UNICEF Malawi administers the Humanitarian Drone Testing Corridor in Kasungu and manages the application process (together with DCA). They also provide technical and logistical guidance and overall coordination for corridor partners.

3) **The Malawi Revenue Authority (MRA)** provides customs clearance for RPAs that are imported into the country. For this purpose, a clearing agent typically facilitates applications.
4) **The Malawi Communications Regulatory Authority** (MACRA) allocates radio frequencies to use during RPA operations for both navigation and communication.
5) **Affiliated Government Institution/Sector Ministry/Department**: Except for strictly corridor testing purposes, RPA operations generally are affiliated with a line government ministry or department, such as the Ministry of Health.
6) **Study Ethical Approvals**: Where human subject are or may be involved or affected, ethical approval to conduct studies and publish results must be obtained from the relevant authorities, such as the Malawi National Health Sciences Research Committee (NHSRC) or the National Committee on Research in Social Sciences and Humanities (NCRSSH).

3.1 Department of Civil Aviation

In recent years, the Humanitarian Drone Testing Corridor has transitioned from a purely experimental zone into the core of the RPA ecosystem in Malawi. The corridor enables development partners, the Government of Malawi, international organisations, RPA companies and academic partners to test and prove their technical capabilities before seeking approvals from the DCA to conduct the RPA-related projects within and beyond the corridor.

3.1.1 Corridor Testing Application

Applications can be completed online on the UNICEF website listed in the Appendix. The testing corridor application is free. RPA operators can apply to simply experiment or test their technology, or as a prerequisite to outside testing corridor operations. DCA requires all operators to test RPA capability, safety and reliability, or a so-called “stress test”, prior to all use in public airspace. The stress test process includes a real-life flight simulation, within the corridor, in order to demonstrate the RPAs technical capabilities and limitations, including communication reliability, and the capacity and reliability of the RPA service operators.

RPA operators are highly encouraged to share their experiences with local stakeholders as part of ‘giving back’ and supporting the local RPA industry capacity development. Additionally, they can discuss suitable topics and identify a convenient mechanism to share experiences with DCA. RPA operators can use this online form, adapted from WeRobotics, to track flight information generated during test flights at the corridor.

For more details on the technical RPA requirements for the stress test, as well as a completed example of the flight tracking tool, please refer to Appendices 7.9 and 7.10.

3.1.2 Outside Testing Corridor Flight Authorisations

After a period of testing at the corridor, companies are evaluated by DCA for flights flown elsewhere. On this basis, DCA reserves the right to approve or deny RPA operation in public airspace. The flight authorisation application for public airspace operations attracts a $100 USD fee.

In addition to successful test flights in the corridor, companies that wish to seek DCA's approval to conduct flights in Malawi airspace (beyond corridor), shall submit the following documentation:

1. Detailed concept of operations, including:
    a. Technical and operational team members' roles
    b. Concept of RPA operations (delivery, mapping or mixed)
    c. Standard operating procedures and practices, including RPAs fail-safe mechanisms and different scenarios
    d. Technical RPA features and capabilities
    e. Technical checklists
    f. Transportation of dangerous (medical) goods
    g. Risk assessment/evaluation, risk management and risk mitigation, including emergency procedures and safety measures
    h. Framework of the training programme
2. Flight logs of each flight undertaken at the corridor during the testing period (in readable .xls or similar format)
3. RPA operator licenses (Check with DCA whether your foreign licenses are recognised in Malawi)
4. Any technical feedback and observations about completed flight tests in the corridor

3.1.1.1 Safety and Fail Safe Mechanisms

RPAs planning to fly outside the corridor require a safety and fail-safe mechanism, including the following:

1. ADS-B transponder
2. Return to base or hover emergency facility
3. Communication link redundancy (alternative LTE, Radio, or satellite link)

3.1.1.2 Air Traffic Control Communication

Any beyond visual line-of-sight (BVLOS) RPA flight, in Malawi, has to be approved by air traffic control (ATC). Additionally, for each RPA BVLOS operation, DCA issues a Notice to Airmen (NOTAM), informing other air traffic controllers about the RPA operations taking place and the given location and airspace. A request for NOTAM has to be submitted to air traffic control and the DCA at least five days prior to the launch of operations.

A dedicated WhatsApp group, called Malawi Drone Operations, administered by UNICEF and DCA staff, has been created that includes multiple (un)manned aviation stakeholders in Malawi, including flight operators, air traffic controllers, pilots, RPA operators and others. This group was created to coordinate each BVLOS flight taking place within or outside the corridor and is actively used.

DCA is using an Unmanned Traffic (UMT) System in the Humanitarian Drone Testing Corridor which tracks flights based on ADS-B Technology. Unless using a low-cost consumer RPA (e.g. DJI or Parrot), it is requested to transmit an ADS-B signal from the RPA.

3.1.1.3 Daily Approvals

Companies conducting BVLOS flights, in or outside of the corridor, are requested to share their flight plans (including flight routes, directions, estimated time of arrival (ETA)s, and similar data) the evening prior to flights the following day. Operators should receive approvals from ATC.

In addition, RPA companies are requested to communicate with the dedicated WhatsApp group during the take-off, in-flight (different waypoints), and landing of their BVLOS operations.

3.1.1.4 Stress Tests and Flight Logs

The DCA conducts a practical evaluation (stress tests) of RPAs intending to operate in public airspace at the corridor. The tests are based on the submitted RPA capabilities, including range, navigation and fail safe mechanisms. Additionally, a flight-tracking tool has been introduced to keep track of all flights happening at the testing corridor. Operators are also required to submit their flight logs in readable files (such as .xls) or can use the flight-tracking tool provided.

3.1.1.5 Controlled Airspace

Operators are required to stick to assigned and approved routes and altitude limits, and seek renewed approval from DCA if any adjustments to these data are made. DCA will provide guidance on these.

The following locations are classified “No Fly Zones” in Malawi:

1. State residences
2. Security establishments
3. Foreign airspaces, including embassies and high commissions within Malawi.

The following are restricted areas. They require approvals to fly over.

1. Airports
2. Wildlife reserves
3. Parliament
4. Densely populated areas.

3.2 Malawi Revenue Authority

3.2.1 General RPA Customs and Tax Guidelines

All RPA imports require payment of applicable tax unless otherwise waived by the tax collecting body, the MRA. Tax is payable prior to or upon entry, otherwise authorities will detain RPAs at point of entry until all duty is paid in full.

MRA tax charge for RPAs is comprised of the following;

- 30% Import Custom Duty (ICD)
- 25% Exercise Duty
- 16.5% Value Added Tax (VAT)
- 2% Clearing agent service fee

Note that these are subject to review so always check with MRA when importing RPAs. The percentage calculations are based on the value of the RPA. Services of a clearing agent, which are calculated at a service fee of 2%, are required to process importation clearance with MRA. For further information, please visit the MRA website.

3.2.2 Temporary Importation

Foreign RPA companies coming to the corridor for temporary operations may be eligible for duty-free, temporary importation of RPA equipment used for humanitarian purposes. To obtain this clearance, you must submit an application to the Malawi Revenue Authority **at least one month prior to arrival in Malawi.** The maximum period for the temporary, duty-free importation is six months.

> **Tip #1:**
> Temporary import covers a period of six months. You must apply for a temporary import at least **one month prior** to entry in Malawi.

All relevant documents for duty-free importation can be sourced and downloaded from the MRA website, under "Customs and Exercise". Please note that the equipment list must be very detailed, including the quantities and serial numbers of all hardware items (where applicable).

Ordinarily, clearing items with MRA involves clearing agents. Organisations with experience submitting importation applications, such as UNICEF, VillageReach, or MRA, can recommend a clearing agent used for previous RPA imports.

Below are three temporary import clearance options:

a) *Option A: Ahead of Time Temporary Importation Clearance (Recommended)*

It is recommended that the Department of Civil Aviation be engaged 2-3 months before importation. Note that this process takes time as it is referred to the Commissioner General.

1. DCA will write to MRA requesting temporary importation (duty is waived on the understanding that after the activity the aircraft is exported). Based on an organisation's procurement process, it is suggested to identify a clearing agent to process the temporary importation.
2. Temporary importation should be approved before the RPA leaves for Malawi.

   The clearing agent is bonded until the RPA is exported within the stipulated period. Any overstay will incur penalties.

Option B: Temporary Importation with Refundable Duty Paid

1. This also refers to temporary importation where an application for temporary importation with duty waived was either not submitted or has been declined by MRA.
2. Please indicate that the importation is temporary so that MRA commits in writing to refund duty paid after the activity is complete.

3. The refund is claimed after exportation within the agreed timeframe. This implies that the RPA is physically certified to be exported; this is not applicable if RPA is not presented and exported.
4. This process is less time consuming in terms of processing RPA importation, however, experience shows that the time to refund payments after the export can be long.

b) Option C: Expedited Importation Without Duty Paid (Not Recommended)

1. This is **not recommended** as MRA reserves the right to decline the expedited importation, in which case duty will have to be paid in full or the RPA will be refused entry.
2. Where neither Option A or B have been done, a clearing agent may request for an expedited station manager at the point and time of entry (must be sought during working hours).
3. The clearing agent is bonded until the RPA is exported within the stipulated period. Any overstay will attract penalties.

3.2.3 Permanent Importation

If RPA activities should exceed six months, the importation of the RPA is generally considered permanent unless otherwise stated or agreed beforehand. Permanent importation of RPAs qualifies for customs duty. The payable customs duty depends on the RPA value.

Some development partners/NGOs qualify for tax waivers for different forms of vehicle imports. It may be advisable to apply for this waiver for RPA, as well in the case of NGOs.

3.3 Malawi Telecommunication Regulatory Authority

The MACRA is mandated by law to allocate and manage radio frequencies (RF) use in the country. The Communication Act No. 34, which came into force in 2016, mandates MACRA to manage the implementation of the legislation on behalf of the government. This entails allocation, assignment, and monitoring of RF use. Therefore, it is mandatory that MACRA approval is obtained for the use of all RPAs. Approval is obtained through an application to MACRA, who will then issue the certificate. During this approval, MACRA will conduct an examination of the RPA and its control station, with respect to standards conformance. Notwithstanding the above, usage of RPA without this approval constitutes an offense punishable by law.

Tip #2:
118.1 is the frequency used by regular manned aviation in Malawi airspace.

MACRA refers to RPAs as UAVs. As many RPAs use RF for both navigation and communication, there is potential risk of interference with other RF users including telecommunications companies. This presents a need for coordination between MACRA, DCA and RPA operators. MACRA may assign specific RFs depending on geographical locations. For smooth and safe operations, operators need to observe the following;

1. Bandwidth licensing: Check if the RPA type was already approved by MACRA in the past (even for a different operator), if it was, there is no need to apply for a license. If the RPA type has never received a license in Malawi, the operator must apply for one.
2. Confirm with MACRA the frequencies allocated for RPA use in the area where operations are planned before commencing operations.

In terms of telecommunications, Malawi is in Region 1, together with Europe, so may use similar frequencies. Besides the use of RF, it is also mandatory that both the RPA and the controller be certified for RPA Type Approval prior to importation as specified in Section 2.1.

3.4 Affiliated Government Institutions

Operators planning to conduct operation in public airspace will usually be affiliated to a line ministry or department, for example health, agriculture etc. The line ministry should be engaged prior to commencement of the importation processes. Line ministries usually prepare a letter of support that can be used as part of the importation documentation.

3.5 National Research and Ethics Approvals

For activities classified as a research study, ethics approval is required. Studies in the health sector require ethics approval from the National Health Sciences Research Committee (NHSRC). Click here for further details.

3.5.1 Regular Approvals

Ordinarily, study approvals take time as the NHSRC committees meets quarterly and revisions to study protocols are often required. Planning ahead of time and reaching out to the NHSRC committee for guidance is recommended. For study approval, they charge 10% of the study budget for administration purposes, including monitoring of the study site to ensure compliance to the conditions indicated in the study protocol.

3.5.2 Expedited Approvals

NHSRC can conduct expedited reviews of study proposals upon request. Generally, the applicant must pay an additional 10% convening costs for the committee, totaling the study approval fee to 20% of the study budget.

3.5.3 Student Approvals

NHSRC categorises student studies separately. Student applications follow a slightly different approval process and fees structure. For more information check on the NHSRC contact provided in Appendix 9.1.

Figure 2: DCA conducting community RPA demonstration. Photo Credit: VillageReach

4 WHO SHOULD YOU ENGAGE?

Depending on the design of RPA activities, they will involve a number of stakeholders, including regulatory authorities, government institutions, community leaders, and others. RPA technology is a new and developing innovation in the humanitarian space, including in the Malawian context. However, unlike other technologies, RPAs are highly visible to the public when in operation and can easily affect others within and around the operation sites. Due to this, a wide range of stakeholders need to be consulted and involved in ongoing operations. For activities outside the corridor, the list of officials to be informed of operations include national level, district level and community level stakeholders.

4.1 National Level

National level stakeholders include the DCA, Ministry of Home Affairs, Ministry of Defense, Ministry of Information (MOI), and others. A more specific list depends on the sector in which the RPA activity falls into and what the intended use is. For instance, transporting medical commodities automatically necessitates involvement of the MOHP and related authorities, such as PMPB or the MBTS. The same applies for activities that fall within the areas of agriculture, land, mining, contruction, forestry and so on. The DCA will advise on other stakeholders to engage.

4.2 District Level

Malawi is comprised of 28 districts, which act as the second highest administrative division. The RPA activity will take place at a district level, therefore district level governance institutions become critical stakeholders as the activity may directly or indirectly affect them.

Once national approval is obtained and national level stakeholders support the RPA activity, implementers should proceed to meet with sector-specific district officials (e.g. District Health Officers, District Education Managers, District Aviation Officers, etc.). The national level team will guide who and how to meet district level stakeholders.

With support from sector officials, implementers should brief the District Council Executive Team in order to provide information about intended RPA activity and rally their support. Local government officials, such as the Mayor's Office, Councilors and the police, should be briefed on operation plans. In some cases, implementers may want to engage the local police to secure take-off and landing zones.

4.3 Community Level

Involving community members is paramount for smooth and safe operations. Implementers must be proactive and ensure that community-level stakeholders are meaningfully engaged during all phases of the RPA operation. The following guidelines follow best practices for community engagement and will aid in successful operations.

Implementers should liaise with district council representatives and district-level sector officials to identify and engage community-level leadership, including traditional leaders, representation from the Area Development Committee and/or Village Development Committee, religious leaders, business representatives, elected officials, such as councilors, community law enforcement representatives, and relevant special interest groups.

4.3.1 General Public

While community leaders are expected to communicate with their respective population, implementers are encouraged to plan for community sensitisation and ensure that the communication is effective, complete, correct and presented in time. Sensitisation of the general public should achieve the following aims:

- Create awareness of the project implementation, including RPA flights
- Highlight potential benefits of the intervention and manage expectations
- Assure the public of accident prevention and mitigation measures, as well as community safety and privacy.

To achieve these aims, implementers are encouraged to take the following steps:

1) Conduct an RPA Awareness and Perception Assessment, particularly in areas without previous RPA activities.
    - Work with local experts to design a context-specific assessment tools in targeted intervention areas
    - Segregate special interest groups, minorities and gender for the assessment
    - Target intervention areas

2) Design a stakeholder and community sensitisation plan
    - Identify communication mechanisms (e.g. roadshows, demonstrations, radio, print media)
    - Develop key messages
    - Keep the sensitisation two way – allow the public to ask questions, state concerns, etc.
    - Attend to all concerns raised during the assessment

3) Conduct community sensitisations, sharing information on:
    - The intervention use case and flight operations
    - Roles, responsibilities and rights of various stakeholders
    - Potential benefits of using RPAs
    - Risk factors and risk mitigation
    - Safety and security

Implementers may want to also consider linking community sensitisation to service provision related to the use case. For example, a roadshow for an intervention focusing on transport of HIV samples may be conducted alongside HIV testing services.

5 OPERATIONAL CHECKLISTS

To conduct safe and efficient RPAs implementations, it is very important to prepare a detailed operations checklist. This section covers sample operational checklists, for illustrative purposes. Operators are required to develop their own checklists that are comprehensive and suitable to their specific type of aircraft and protocols.

5.1 Location Checklist

SN	Check	Task	Remarks
1	[ ]	Identify airspace	Operators should ensure that they are allowed to fly within the selected location.
2	[ ]	Check area for privacy concerns	Always be aware of privacy sensitivities. Always make sure the general public is aware of flights in public airspace. Check with civil aviation, local authorities for guidance.
3	[ ]	Check if the area is restricted	It is not permitted to fly near military bases, national parks, or selected government buildings. In certain areas local laws may also apply.
4	[ ]	Check for temporary flight restrictions	Check for active NOTAMS.
5	[ ]	Abide by DCA Regulations	Remain below 400 feet AGL, maintain visual line of sight, avoid flying over highly populated areas, and do not fly at night.
6	[ ]	Maintain visual line of sight	Keep your eyes on the aircraft at all times.
7	[ ]	Be smart and have a plan	Set a perimeter, avoid power lines, consider weather, locate landmarks, plan for emergencies, and use checklists.
8	[ ]	Identify a take-off and landing area	Take-off and landing areas should be flat, free of obstruction, people, and possible interference.

5.2 Pre-Flight Checklist

SN	Check	Task	Remarks
1	[ ]	Verify that all equipment is fully charged	This includes Ground Control Unit, aircraft batteries, and any mobile device or tablet.
2	[ ]	Visually inspect the RPA	Physically examine the RPA and all gimbals, payloads, and props for visible defects.
3	[ ]	Remove gimbal clamps	Gently remove gimbal clamps.
4	[ ]	Check props	Make sure that props are properly attached and secure.
5	[ ]	Turn on remote control	Always power on ground control equipment before the aircraft system.
6	[ ]	Power up	Add fully charged battery to the RPA and power on the battery.
7	[ ]	Launch the flight control app	If using flight control app.

SN	Check	Task	Remarks
8	[ ]	Verify system status	Firmware versions, flight mode, datalink strength, payload status, battery status, and onboard sensor statuses.
9	[ ]	Set/verify return-to-home height (RTH)	This should be based on the height of the tallest obstacle within the flight area.
10	[ ]	Set/verify maximum flight altitude	Use to ensure compliance with MDCA rules for maximum flight altitude, if available.
11	[ ]	Perform a compass calibration if required	Verify GPS signal strength and number of satellites connected. Be aware of the potential for losing GPS positioning capability in any area where less than 10 satellites are able to connect to the RPA.
12	[ ]	Confirm GPS satellite control	Follow manufacturer instructions for when and how to calibrate the magnetometer (compass). It is considered best practice to calibrate whenever testing is moved more than 80 kilometers from previous flight area.
13	[ ]	Check map	Do a quick map check on the app monitor to make sure the icon indicating the GPS recorded launch position represents the actual location.
14	[ ]	Check and confirm camera and gimbal settings (If applicable)	Auto iris, white balance, shooting resolution, frame rate, file type, gimbal mode, etc.
15	[ ]	Designate potential emergency landing locations prior to takeoff	Identify safe and convenient landing points for emergency landing along your designated routes

5.3 Take Off Checklist

SN	Check	Task	Remarks
1	[ ]	Maintain flight line	Complete a final check to be sure all bystanders are clear. If people are standing too close, ask them to stand back.
2	[ ]	Check multirotor prior to take off	Conduct a final check of RPA controls, datalinks and overall system status. Upon takeoff, execute an initial hover at 8-10 feet. Perform a quick status check on the monitor to make sure everything is in order (Global Positioning System [GPS] control, datalink strength, battery levels, etc.) then proceed with the flight.
3	[ ]	Verify baseline settings	Verify all baseline settings in the primary flight control software are correct prior to initialising any autonomous flight software.

SN	Check	Task	Remarks
4	[ ]	Configure autonomous flight profile	Configure settings in the autonomous software platform based on specific flight area conditions and data collection requirements.
5	[ ]	Perform pre-launch check	Execute either an automated or manual check of all critical system functions.
6	[ ]	Clear take off area	Ensure the take-off zone is clear of bystanders and that the RPA is properly positioned for launch.
7	[ ]	Perform pre-launch check	Execute either an automated or manual check of all critical system functions.
8	[ ]	Clear take off area	Ensure the take-off zone is clear of bystanders and that the RPA is properly positioned for launch.
9	[ ]	Fixed wing take off	Ensure adequate space in all directions based on launch and recovery procedures. Conduct a final check of RPA controls, datalinks and overall status. Launch/takeoff into the wind using the appropriate method (hand-launch, catapult, etc.).
10	[ ]	Fly and capture flight data	Capture any required footage or data. Maintain visual line of sight. Be aware of obstacles that create a risk of distraction/disorientation. Make sure to thoroughly practice basic flight exercises before flying with hazards nearby. Be safe and remember to always have fun.
11	[ ]	Constantly check RPA battery levels	Make sure there is enough battery to return in plenty of time. It is recommended to set the low battery warning to 25%-30%, or follow manufacturer guidelines. Remember to plan for reduced flight times if air temperatures fall outside of acceptable ranges, or if GPS positioning hold requires additional power output due to high winds.
12	[ ]	Verify baseline settings	Verify all baseline settings in the primary flight control software are correct prior to initialising any autonomous flight software.
13	[ ]	Configure autonomous flight profile	Configure settings in the autonomous software platform based on specific flight area conditions and data collection requirements.
14	[ ]	Initiate autonomous flight	When ready ,initiate autonomous flight
15	[ ]	Monitor the RPA's location and system status	Maintain line of sight contact with the aircraft throughout the autonomous flight profile. Monitor system information and flight progress on the flight display.
16	[ ]	Be prepared to assume control	In the event of a system malfunction during autonomous flight operations, the pilot must be prepared to resume

SN	Check	Task	Remarks
			manual control and execute emergency procedures if necessary.

5.4 Landing Zone Checklist

SN	Check	Task	Remarks
1	[ ]	Ensure landing area is clear	Ensure the landing zone is clear of bystanders and debris.
2	[ ]	Return multirotor aircraft to the landing zone	Maneuver the aircraft into position for landing in the designated area. Whenever possible, land into the wind to reduce ground speed and facilitate a soft touchdown.
3	[ ]	Conduct an autonomous or manual landing	Be sure to understand how the aircraft will function when under autonomous control. If manual landing is executed, perform a motor shutdown upon landing.
4	[ ]	Power down	After landing, turn the RPA off first. Then turn off the ground control unit and the Flight Control App.
5	[ ]	Complete flight log and post-flight maintenance checks	Document flight details soon after a flight is completed, on location.

6 LEARNING FROM EXPERIENCE

This sections summarises Malawi's RPA experiences across use cases to date, draws on lessons learned, and is shared in the spirit of transparency and to promote RPA technology in Malawi and beyond. Most of the experiences are drawn from the corridor, as this is where most activities have taken place. These experiences can be applicable elsewhere, and where necessary the toolkit will indicate the contexts other than the corridor.

The overarching advice is to ensure advanced preparation; reach out to various authorities, review available resources and ask questions ahead of time. This will save time and resources that can be utilised for actual implementation.

6.1 Management of Stakeholder Expectation

Many questions and misconceptions can still exist. It is recommended that for every project, the goal(s) should be reviewed to reset expectations. This would include aircraft capabilities and limitations, risks and mitigations measures in place.

6.2 Importing Polymer Lithium Batteries

Airlines often have restrictions on the transportation of polymer lithium batteries (PLB). Find out from travel agents or the airline directly if a given carrier permits the transport of PLBs ahead of time. Shipping can take as long as three months, in some cases, and implementers should plan accordingly. Consider this website for advice regarding travel with PLB batteries.

6.3 Local Assistance

For activities within the testing corridor, it is recommended to hire a local intern or assistant whom is able to speak the local language, Chichewa, and assist throughout the tests. UNICEF and/or DCA can provide suggestions from a pool of former interns. They will also be able to assist with general safety and crowd control, as the tests always attracts local children. Usually, the daily rate for an intern is approximately $40 USD.

6.4 Testing Duration

In order to obtain approval for flights outside of the corridor, RPA operators must complete a series of test flights within the corridor. The number of test flight days depends on the demonstration of successful flights based on agreed parameters with DCA. This varies depending on RPA type, intended use and planned flight location(s).

However, most of the corridor partners plan anywhere between 10 and 14 days total for the testing of an RPA. The first week is often for setup and scouting and preparations, while the second week is intensive in conducting flights and demonstrating the technology for local, regional and national stakeholders, including the DCA.

6.5 Electricity

During the dry season (mid-May to mid-November), power cuts may last 6-8 hours, with a possibility of full days without electricity. The situation improves during the rainy season (mid-November to mid-April). Electricity Supply Commission of Malawi (ESCOM) provides a blackout schedule, but this is not always adhered to.

The Kasungu aerodrome does have electricity and a refrigerator, but no backup generator. Therefore, renting a generator is strongly advised. The two hotels (links here and here) in Kasungu both have backup generators.

Those using the corridor are required to procure electricity units (about $2 USD per day), water and toiletries for their own use during their stay at the corridor. Please liaise with DCA or UNICEF on how to make electricity purchases.

6.6 Transport

Road quality in Malawi can be unreliable and a 4x4 pickup truck is essential to include in budgetary planning, especially if large RPAs and accessories are to be transported. Make sure to rent a vehicle or have a project partner supply one as transportation costs can add up quickly. After arriving at the corridor, it can be very difficult to move around without access to a rented vehicle or hired taxi; Uber does not operate services in Kasungu.

6.7 Parts and Supplies

Spare parts, tools, and electronics can be hard to come by in Malawi. We recommend that implementers come fully prepared for field operations with all the parts and spares needed for eventual repairs. This can be as simple as super glue, two-sided tape, and other items that may be readily available elsewhere, but are non-existent or very difficult to find in the country. If using a fuel powered RPA, contact primary importers directly to avoid fuel contamination and ensure the RPA is equipped to filter the most extreme contamination of fuel.

> **Tip #3**:
> When in doubt for which parts and supplies to pack—**if you think you need it, take it!** Even something you consider basic may be difficult to find while on location.

6.8 Software

Make sure to download all necessary software, firmware, and similar things to laptops and ground control stations prior to coming to Malawi. Due to limited Internet speed and high costs, it may be difficult to download large amounts of data or software.

6.9 Altitude and Weather

There are three seasons in Malawi. December to March we experience a rainy season, during these months expect rain with heavy showers, 2-3 hours a day. April to August is the dry, cold season with hardly any rain and lower temperatures in the evening (5-10°C), while temperatures during the day reach about 25°C. September to November is the dry hot season, with temperatures reaching above 30°C. The Kasungu aerodrome and test corridor are located at roughly 1000 m above sea level. On average the wind is around 5 m/s and usually picks up in the afternoon, so expect gusts of ~15 m/s. Click here for more information or visit the website of the National Meteorological Department.

> **Tip #4:**
> The corridor is at about 1000m above sea level and experiences average wind speeds of 5m/s.

6.10 Radio Frequency Interference

The transmitting power of the cellular towers in Malawi is unusually strong. This could potentially cause frequency spillage that can interfere with other frequencies like the GPS L1 band. We recommend implementers:

- Have a radio frequency scanner with them
- Use at least L1, L2 band GPS (L5 too, if possible).

- Dual GPS setup for increased redundancy
- Contact MACRA to acquire accurate positioning of cellular towers
- Ensure the RPA autopilot handles well the GPS loss failsafe procedures and recovery.

For reference, below is a map of all cell phone tower locations within the corridor.

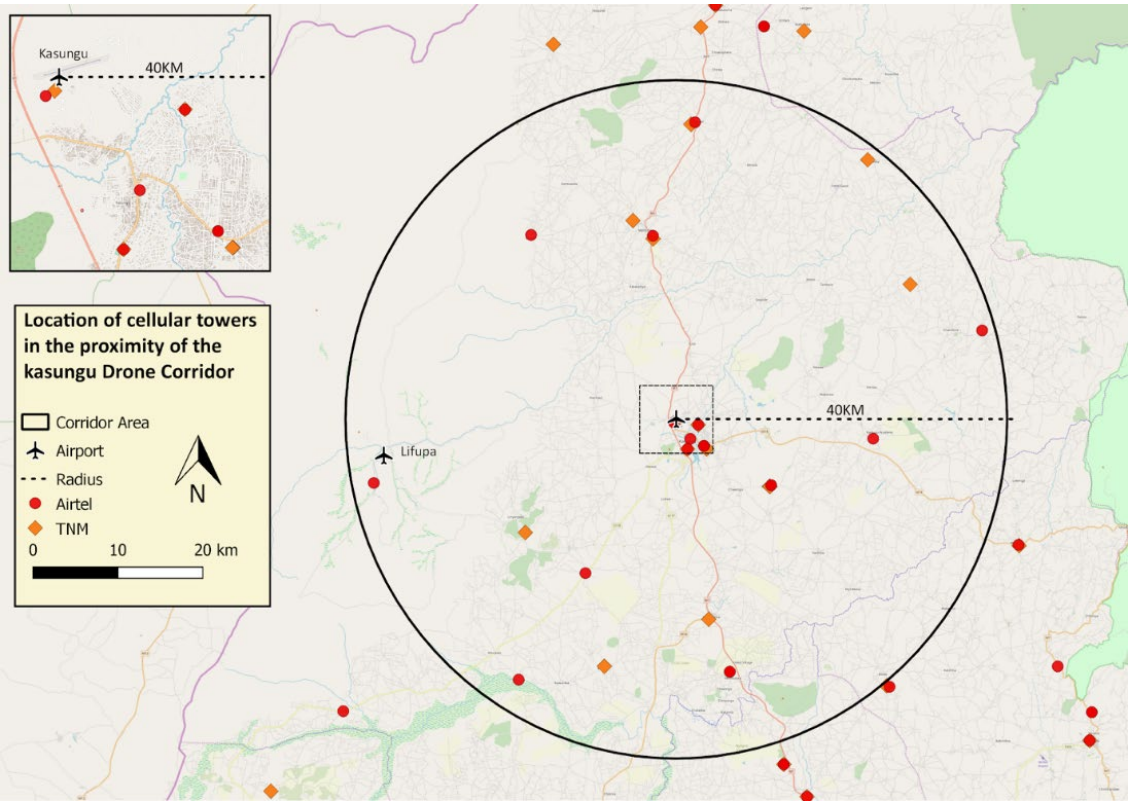

Fig 3: Map of TNM and Airtel towers.

6.11 Mobile Phone Coverage and Communication

There two primary mobile network operators in Malawi, Airtel and TNM. The coverage information for TNM can be found here, and for Airtel can be found here.

If an RPA depends exclusively on 4G LTE coverage, there will likely be difficulties using the whole corridor. Kasungu town is covered by 4.5G, but the connection in the countryside is less reliable. Please be advised that there are wide areas of the testing corridor without any mobile phone connectivity. Therefore, having a satellite fallback connection is highly advised for RPA navigation.

Tip #5:
It is highly recommended to have satellite fallback connection.

The locations of all cellular towers (both, Telecom Networks Malawi [TNM] and Airtel) can be found here (the list is constantly updated).

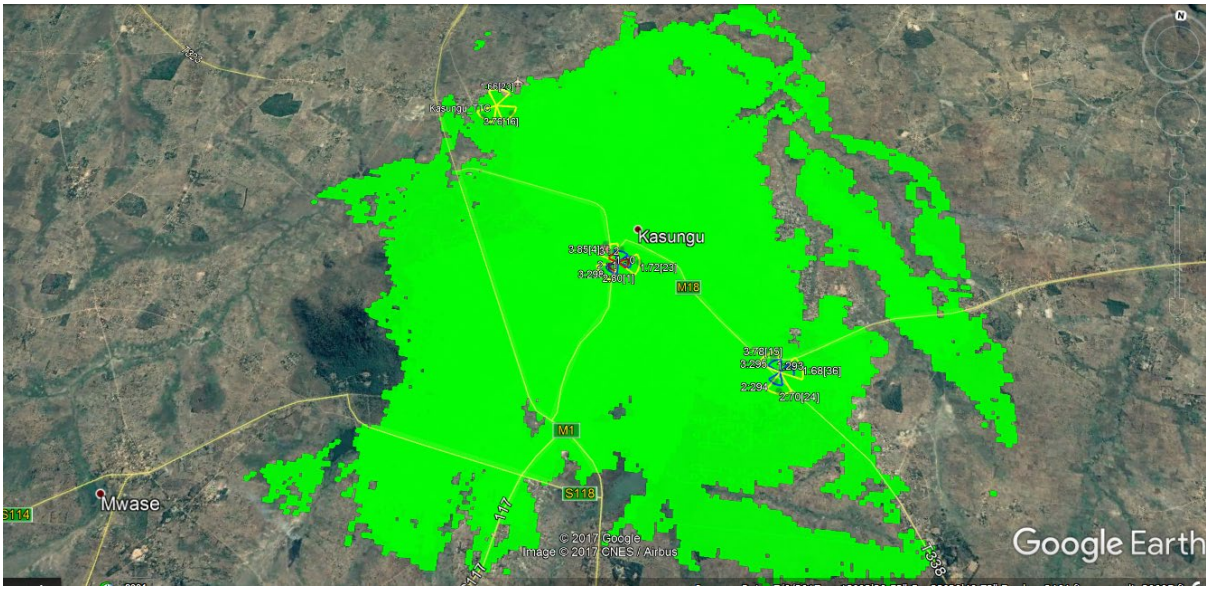

Fig 4: Map of TNM coverage over downtown Kasungu town. For more information, click here.

Additionally, regular radio frequencies used for telemetry are used for mobile networks according to MACRA. Please check with MACRA (see section 2.3) for frequencies to use for both RPA navigation and communication in the specific area for conducting operations.

6.12 Internet Connectivity

Although Kasungu Inn and Chikho hotels have Wi-Fi hotspots (Internet is provided by Skyband, and 2GB of data cost approx. $5 USD), it is advisable to use mobile network on a mobile device using a local SIM card. SIM cards can be purchased at the airport or practically anywhere via street vendors. Data bundles can be purchased together, which is more cost effective.

Tip #6: If the telemetry is Internet dependent, be sure to have Wi-Fi dongles that work with different SIM cards to ensure the stability of Internet connection throughout testing.

6.13 Operational Capacities

Based on experiences of past corridor testing, it is essential that RPA companies have standard operating procedure in place, which help accelerate the entire testing process at the corridor. This is also a requirement for flight authorisation from the DCA. The overall experience depends on how efficient the operation is. It is also key to have personnel with previous RPA deployment experience, are capable of fixing software and hardware issues, and have RPA maintenance skills. Having experienced operators help

solve issues quicker and with less effort. This allows the RPA testing operation to maintain the focus on flying, as opposed to spending time fixing small technical issues.

This also applies to those planning to fly outside the corridor. The concept of the corridor is to promote technology and skill development. Those wishing to test their technology and expand their skills are encouraged to practice within the corridor.

6.14 Aggressive Birds

Malawi RPA operators have experienced bird attacks on their aircrafts. Please consult local operators for further information regarding bird attacks. Also take measures to prevent bird attacks including avoiding nesting locations.

6.15 Petroleum Quality

Petroleum impurities have been known to affect and block the engines of fuel powered RPAs. Please obtain fuel from authorised suppliers and test for quality. Also note that petroleum in Malawi is blended with ethanol. For more information, please check with the Malawi Energy Regulatory Authority (MERA) through their listed contact in Appendix 9.1.

6.16 Infrastructure Locations and Topographical Maps

Topographical maps for an intervention area can be obtained from the Department of Surveys, using the contacts provided in Appendix 9.1. In case of other infrustucture inquiries, please discuss with the DCA for guidance on the appropriate institutions to approach. The following are examples of infrustucture and the corresponding organisations to contact:

1. Schools: Ministry of Education, Science and Technology
2. Health facilities or laboratories: Ministry of Health and Population Services
3. Laboratories: Ministry of Health and Population Services

7 SUPPLEMENTARY INFORMATION

7.1 Emergency Standard Operating Procedures

Operators are encouraged to have an emergency protocol that clearly assigns responsibilities and resources in the case of an accident, directly or indirectly caused by RPA operations. Appendix 9.6 provides an example of an emergency SOP.

7.2 Bare Minimum Pack

The following is a list of items and accessories beyond those needed for the RPA that one should consider arranging or taking to an operation site.

SN	Item	SN	Item
1	Local SIM cards (2 weeks 16GB – includes for ground station	15	Structural tape, Velcro, etc.
2	Generator	16	Rental Car (ideally 4x4)
3	Arrange for work space – hotels are small with low lighting	17	Driver's license
4	Gaffer tape, double sided tape	18	Tall directional antennae
5	GPS trackers	19	Power strips and cords
6	USB hub	20	Drinking water
7	Power converter and adapters (standard wattage is 220UK)	21	Sunscreen
8	Glue	22	Mosquito repellent
9	Toolkit	23	Emergency light/torch or headlamp
10	Inverter	24	Toiletries
11	Foam	25	Tent for shade
12	Soldering iron or station	26	Cordoning material for designating landing sites outside testing corridor
13	First aid kit	27	Cordoning material for designating landing sites outside testing corridor
14	Extra battery chargers for phones		

Table 1: Bare Minimum Item List

7.3 Travel Advice

7.3.1 General Safety

Malawi is generally a safe country. We do however advise against driving long distances in darkness due to difficult road conditions and the dangerous driving of other motorists. Kasungu town, where the testing corridor is located, has a police station and is generally safe. Kasungu police are well aware of the RPA corridor.

7.3.2 Food Safety

The following provides guidance on food safety when visiting Malawi.

1. **Only** drink bottled water.
2. Avoid eating raw food, especially meat and fish, eggs and unpasteurised milk. Only eat raw fruit and vegetables that can be peeled or hulled. The NHS provides a list of foods to steer clear of when travelling abroad.
3. Always wash your hands after handling, peeling, or hulling raw fruit or vegetables.
4. Only eat food that is well cooked. Avoid eating foods that appear undercooked or that have been sitting out for an unknown amount of time.
5. Exercise caution when buying food from street vendors. Look for popular venders that are serving piping hot food and avoid food that has been sitting out for too long or has gone cold.

7.4 Frequently Asked Questions

This section covers frequently asked questions that operators/implementers should expect from Malawian authorities and local partners. Note, for this section we use the term drones as that is more recognisable to the public.

1. How far can the drone fly?
2. How much can the drone carry?
3. How is the drone controlled? Where is the pilot located?
4. How is the privacy of citizens protected? How can we know that pictures are not being taken by the drone without consent?
5. What happens if the drone falls out of the sky and injures people or damages property?
6. Who owns the drone?
7. How can you guarantee the safety of citizens?
8. Are you replacing conventional transportation?
9. Why are you testing this technology here?
10. Has the technology been previously tried elsewhere? What were the findings, evidence?
11. Who will pay for the operations? Is this technology sustainable in a country like Malawi?
12. Why not just repair land vehicles instead on introducing cargo drones?

7.5 Cost Estimates of RPA Activities

The table below includes a list of estimated costs associated with conducting RPA activities in Malawi. Costs are indicative and may vary.

Table 2: Provisional Costs for Malawi RPA Activities

Item	Price ($;USD)	Comments
Round-trip flights from the US, Europe, and Asia to Malawi	1500 – 2000	Price per person
Hardware logistics	Depends on weight, distance, carrier, etc.	If RPA components travel as cargo, freight forwarders are used for handling all components of the logistics. There are 2-3 cargo flights per week to Lilongwe.
Accommodation	Average of 65 – 75 per night	Lilongwe is more expensive than Kasungu, but the majority of time will be spent in Kasungu. Prices in Lilongwe are frequently above $100 USD per night.
Local transport	60 – 70	Per day including driver, fuel, mileage, insurance
Local SIM card with data	20 – 30	Includes 10-15 GB of data
Fuel	1.20 per litre	Prices fluctuates depending on the market.
Power generator	300 – 500	Price depends on the size and power, however, a generator can be hired as well.
Food	15 – 20	Per person, per day in Kasungu (Lilongwe prices are considerably higher).
Visa	75	Price per person for a single entry tourist visa (only available with cash at the airport; Category 2)
Vaccines	400 – 800	Depending on existing vaccine coverage. Yellow fever vaccination is obligatory to enter Malawi.
Malaria prophylaxis	70	Per 12 pills (1 pill per day)
International travel insurance	Depending on country/scope	Advisable to have medical emergency evacuation coverage
Folding table (for ground station)	100	Arrange with local contacts in advance to identify and select source options that are affordable and convenient for you
Tent (for ground station)	120	Arrange with local contacts in advance to identify and select source options that are affordable and convenient for you

8 Conclusion

This RPA Toolkit is meant to assist operators and implementers to prepare for RPA flights in Malawi. It is essential that they read this toolkit prior to RPA activities.

Activities, such as approvals and community sensitisation are requirements in Malawi and cannot be avoided. While the information provided here can help, it is important that operators and implementers closely collaborate with the DCA, the relevant government Ministries, the RPA Steering Committee, and local companies and organisations for the latest available information.

The RPA community is hoping for the continued successful use of RPAs in Malawi to improve the lives of our people and therefore continues to encourage transparent sharing of lessons learned and valuable experiences made.

Should you have any suggestions to improve this toolkit, please coordinate with the RPA Steering Committee Secretariat, VillageReach.

We wish you all the best on your flight activities!

9 APPENDIX

9.1 Contact List

Organisation Category				
A. Government Departments				
Sn	Organisation	Website	Contact #	Email
1	Department of Civil Aviation	http://www.malawi.gov.mw/		
2	Ministry of Health and Population	http://www.health.gov.mw/index.php/contact-moh/head-office	+265 1 789 400	
3	National Health Sciences Research Committee	https://www.ncst.mw/?page_id=366		ohdoccentre@gmail.com
4	Department of Surveys	http://www.lands.gov.mw/index.php/departments/surveys.html		
5	Department of Disaster Management	http://www.ovp.gov.mw/		
6	Ministry of Information Communication and Technology	http://www.ict.gov.mw/	+265 1 772 702	Principal.secretary@information.gov.mw
7	Ministry of defense	http://www.malawi.gov.mw/		
8	Ministry of Justice	http://www.malawi.gov.mw/		
9	Ministry of Natural Resources Energy and Environment	http://www.malawi.gov.mw/index.php?option=com_content&view=article&id=75&Itemid=20		
10	Ministry of Education Science and Technology	http://www.malawi.gov.mw/		
B. Statutory Corporations (semi –government organisations)				
Sn	Organisation	Website	Contact #	Email
1	Malawi Communications Regulatory Authority	Macra.org.mw	+265 1 810497 +265 1 810924	dg-macra@macra.org.mw info@macra.org.mw
2	Malawi Revenue Authority	Mra.mw	+265 1 822 588	mrahq@mra.mw
3	Malawi Blood Transfusion Services	http://www.mbtsmalawi.com/index.php/contactus	+265 1 870 522 +265 1 872 650 +265 1 874 666	mrcs@redcross.mw

Organisation Category				
4	Pharmacy Medicines and Poisons Board	http://www.pmpb.mw/	+265 1 755 165	info@pmpb.mw
5	Malawi Red Cross	https://www.redcross.mw/	+265 1 775 590	mrcs@redcross.mw
6	Electricity Supply Commission of Malawi	http://www.escom.mw/#	+265 885 979 +265 885 650 +265 1 822 000	info@escom.mw
7	Malawi Energy Regulatory Authority (MERA)	https://www.meramalawi.mw/	+265 1 774 103 +265 775 810	mera@meramalawi.mw
C. Non-Governmental Organisations				
Sn	**Organisation**	**Website**	**Contact #**	**Email**
1	VillageReach	https://www.villagereach.org/	+265 999 210 567	info@villagereach.org
2	UNICEF	https://www.unicef.org/malawi/contact-us	+265 1 770 770	lilongwe@unicef.org
3	GHSC- PSM	https://www.ghsupplychain.org/contact-us		PSMCountryProgramsCore@ghsc-psm.org
4	CSR	https://www.crs.org/our-work-overseas/where-we-work/malawi		
5	DFID	https://www.gov.uk/world/organisations/dfid-malawi	+265 1 755 165	info@pmpb.mw
6	University of North Carolina	https://www.med.unc.edu/medicine/infdis/malawi/	+265 1 755 056	administration@unclilongwe.org
7	German Development Corporation (GIZ)	https://www.giz.de/en/worldwide/341.html	+265 099 500 127	giz-malawi@giz.de
D. Local Universities				
Sn	**Organisation**	**Website**	**Contact #**	**Email**
1	Lilongwe University of Agriculture and Natural Resources (LUANAR)	http://www.bunda.luanar.mw/luanar/contact_us.php	+265 1 277 222 +265 1 277 260	pro@bunda.luanar.mw
2	Chancellor College of the University of Malawi	https://www.cc.ac.mw/	01 524 222	registrar@cc.ac.mw
3	Malawi University of Science and Technology (MUST)	https://www.must.ac.mw/	+265 1 478 000	registrat@must.ac.mw
4	Mzuzu University (MZUNI)	https://www.mzuni.ac.mw/	+265 1 320 722 +265 1 320 575	ur@mzuni.ac.mw

Organisation Category				
5	Polytechnic	https://www.poly.ac.mw/	+265 1 871 637	principal@poly.ac.mw
	E. Local RPA Companies			
Sn	**Organisation**	**Website**	**Contact #**	**Email**
1	Precision Inc	www.precision.mw	0888879999	owen@precision.mw
2	Mamabird	http://mamabird.io/#content-21	+ 265 992164687	hello@mamabird.io
3	Flying Labs	http://flyinglabsmw.com/	+265 992 164 687	Info@Flyinglabsmw.Com
	F. Global UAV Coordinating Forums			
Sn	**Organisation**	**Website**	**Contact #**	**Email**
1	UAV Payload Delivery Working Group (UPDWG)	https://www.updwg.org/		info@UPDWG.org
	G. Global UAV Coordinating Forums			
	Organisation	**Website**	**Contact #**	**Email**
	Chikho Hotel	www.africaphonebooks.com	01 253 844 0998 072 200	chikhohotel@gmail.com
	Kasungu Inn	www.infomalawi.com	265 01 253 151	

9.2 Online Corridor Registration

The link to the online corridor application can be found here.

A detailed guide for all corridor partners can be accessed here.

9.3 Cellphone Towers

The cellphone towers locations for both, TNM and Airtel, can be found here

9.4 Stakeholder Sensitisation Strategy

UAV Community Sensitisation Strategy.

9.5 Example Emergency Standard Operating Procedure and Emergency Checklist

UAV Emergency Checklist.pdf

Emergency SOP.pdf