

# Unmanned Aerial Vehicles as a Tool for Managing African Elephants



Wildlife Manager Training & Field Trials, Tarangire National Park, Tanzania February 16-20, 2015



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*Biodiversity & Wildlife Solutions*



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A Collaborative Project of the United Republic of Tanzania; Tanzania Wildlife Research Institute (TAWIRI); Ministry of Natural Resources and Tourism (MNRT) Wildlife Division (WD)–Problem Animal Control Unit; Tanzania National Parks (TANAPA); Mara Elephant Project; RESOLVE’s Biodiversity & Wildlife Solutions & WildTech Project (BWS); Honeyguide Foundation; Wildlife Conservation Society, and DJI

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randy jay braun

# **Unmanned Aerial Vehicles as a Tool for Managing African Elephants**

## **Advanced Wildlife Manager Training & Field Trials, Tarangire National Park, Tanzania February 16-20, 2015**

### **Summary**

In recent tests, quadcopter unmanned aerial vehicles (UAVs) are showing promise as a tool for wildlife managers to move elephants away from farms and communities, reducing human-elephant conflict (HEC) and creating safer conditions for managers in the field. We conducted field trials and advanced training with eight rangers, game officers, and game scouts at Tarangire National Park, Tanzania from February 16-20, 2015. Qualifying rangers were selected based on proficiency and skill shown during the basic training course conducted in November, 2014. Using two models of the DJI Phantom UAVs, we trained wildlife managers in the use of UAVs as a tool to help them achieve their mission goals of moving elephants away from crops and communities and for attending to wounded animals, as well as other management activities for which safe and effective means of moving animals from one area to another would be useful.

The wildlife managers were trained as pilots, gaining further familiarity with the aircraft, covering advanced pre-flight, flight, post-flight, and maintenance operations, with an emphasis on safety. Since these rangers had completed basic training, we focused on specific maneuvers and tactics that are useful for moving elephants in a safe manner, including 'herding' maneuvers and tactics, moving vehicle deployment, decision-making in the field regarding situations where deployment is warranted and those where it is not advisable, and chili-powder and torch deployment attached to the UAV. The wildlife managers built on their solid base of flight skills to work on advanced combination maneuvers specifically useful for moving elephants and quickly deploying the UAVs in the field, particularly at night. They also took on a larger role in taking care of the equipment pre- and post-flight, including maintenance and troubleshooting. Overall, they came away with the knowledge of how to humanely and safely use this tool to support their missions.

The workshop was led by Marc Goss and two Mara Elephant Project (MEP) rangers, Dickson Njapit and Steve Ekeno. The course was designed to get the rangers to think like pilots: being responsible for the aircraft; safety and best practices for use; defining mission objectives; and basic strategy and tactics for moving elephants during the day and night. The workshop was also a learning opportunity as we experimented with different approaches for deploying chili-powder and night flying tactics in farms surrounding the national park.

### **Field Trials with Elephants**

Several proof-of-concept flights were conducted with wild elephants within the Wildlife Management Area (WMA) adjacent to the park. We observed an immediate and organized flight response of groups of elephants to two simultaneously airborne UAVs in four field trials; rangers were conducting practice sessions and were not in attendance,

given they had seen the previous flights in November. We attempted to locate raiding elephants on all four nights to test the viability of this technique in low light conditions. However, we received no calls. Night flying with elephants remains the largest gap in our testing, mainly due to the low levels of raiding occurring since the program has begun. We hope to test the efficacy of UAVs for night operations within a month, during March 2015.

### **Response to UAVs**

Four daytime-field trials were conducted in varying levels of tree and shrub density. In all cases, the elephants were observed browsing and grazing, and had little to no response to the arrival of our vehicles. Responses to the UAVs were similar in all four tests, with elephants taking immediate and organized flight (that is, bunching up and moving off rapidly as a unit in the same direction – ears out and tails high) within the first minute of the UAV being launched and showing very little vigilance or aggressive behavior. No flight lasted longer than 2:40. No chili powder or strobe lights were used in any of the field trials during this training.

The flights demonstrated that elephants in two different areas (Maasai Mara and Tarangire National Parks; the former trials being conducted from September 2014 through the present) could be effectively herded using UAVs. Further field trials are required to understand the full range of conditions under which the UAVs may or may not be effective, including while they are feeding in crops and at night. However, the immediate and pronounced reaction and ability to continuously move the animals for up to 20 minutes showed that they respond strongly to the UAVs (without chili powder) when they are flown with effective herding tactics.

### **Data Collection on Elephant Response**

The response of elephants to UAV use will be documented by rangers using data sheets that record different features and conditions of each field use of the UAVs with elephants. A short communication is currently being prepared based on the data from 10 recorded flights since September 2014.

Rangers were instructed on how to fill out the sheets, and decided that having a pre-determined person responsible for filling out the data sheet would be the most effective way to make sure they are filled out in the excitement of the mission. This means a minimum of four people is recommended for a UAV-HEC response team: pilot, co-pilot, driver, and data collector.

TAWIRI will be coordinating the collection and analysis of response data. Wildlife Division, TANAPA, MEP, and BWS will contribute to the overall analysis, as well.

### **Lessons Learned & Improvements for the Future**

Our review of the training has provided us several lessons learned and suggestions for future improvements. The rangers came away from the training with a good foundation of piloting skills and the length of the training provided us with the opportunity to cover more tactical flying and maintenance issues. However, the absence of local crop raiding

elephants during the training prevented us from testing efficacy of UAVs at night. The rangers have also not been able to extensively fly with elephants, due to the low levels of crop raiding occurring during both trainings. For future workshops, timing of the crop raiding season should be considered when planning the training dates, especially for advanced courses where pilots should be ready to fly with elephants.

### ***Herding Skills & Tactics Important***

The extended length of the training allowed us to focus on the link between the maneuvers during practice sessions, and how they translated into effectively and safely (for both humans and elephants) moving elephants. Flying skills, such as the quick stop and fast lateral sweeps (the ‘TAWIRI turn’), are essential to master for herding elephants safely and efficiently. We employed several drills where rangers simulated elephants—in either a group or individuals—and the pilots simulated moving them in the desired direction. A full description of the training drills can be found in Appendix 1. More emphasis on ‘herding’ tactics with practice in the field is recommended, especially for night operations. Subsequent training and practice sessions should be established for the rangers after the workshop so that they can continue to build their pilot skills. Working with a particularly proficient group of ranger-pilots who can continue to train the others is an optimal approach. We also emphasized that deciding to not deploy a UAV is a tactic, depending upon the situation and the rangers’ assessment of risk.

### ***Maximizing Flight Time***

A key consideration is how to arrange each day so that there is not too much downtime between flying sessions, due to limited battery life and recharging time requirements. Maximizing flight time should be a primary goal. We used parallel charging boards and more batteries to decrease charging time. We also lowered the ratio of rangers to UAVs, so that each ranger got more time flying per session.

### ***Identifying Ace Pilots – Rangers Training Rangers***

This second training was made up of the best pilots from the previous training. Trainers should continue to identify the best potential pilots over the first flight sessions and may want to focus the training on these individuals (especially if batteries and UAVs are limited), allowing them more time with the controls in their hands. This would allow these qualified pilots to begin teaching other rangers, increasing the strength, sustainability, and geographic reach of the program. The two Kenyan rangers, Dickson and Steve, were trained by the Mara Elephant Project, and professionally conducted the training.

This specialist group could also become *de facto* response units, assigned to different Tanzanian regions, ecosystems, or priority elephant landscapes or HEC zones, and travel to HEC hotspots with habitual raiders during the crop-ripening season. TAWIRI felt that working closely with Village Game Scouts was a good approach as they are closest to the crop raiding and can respond fastest, they are part of the local communities, and they are not transferred from one area to another as some rangers are at times.

### ***Training UAVs***

The UAVs at the training handled multiple crashes well, and all were still functioning at the end, but damage to UAVs during training could be minimized in the future by having cheaper ‘training UAVs’. If UAVs are donated, this approach will not leave a battered squadron with the rangers. New prototypes, especially those that are water- and dust-proof and crash-resistant, may make this approach cost-effective.

The DJI crew mentioned that the Phantom 1 and FC40 are the most resilient of the Phantom lineup. Fewer outside moving parts in these UAV models make them particularly good at remaining in the air after multiple crashes.

### ***Maintenance Considerations***

Given that UAVs will be used in challenging field conditions it was important to analyse the potential damages to the equipment that would act as barriers to effective use. The DJI employees explained that certain parts of the UAVs were more likely to become damaged than others. The probability of damage, from most likely to less likely, is as follows:

- Propellers
- Screws
- Motors
- Batteries
- Motor circuit boards
- Compass unit
- GPS unit

Spare parts should be obtained so that a stockpile of the most breakable parts are on hand for when required. We covered how to open the UAV when it is damaged, how to replace propellers, and we covered how parts connect so that they would be able to replace more complicated parts.

At future advanced trainings, more emphasis should be put on advanced UAV maintenance; this would involve classroom sessions for replacing complex parts, such as motors and the GPS unit, which would require soldering to fix.

### ***Night-Flying***

Night operations will be essential for crop-raiding mitigation as most raiding occurs after dark. Safe operation and night-herding tactics are both essential part of a robust training course. We conducted four night flying training sessions.

Using the simulated elephant drill, we experimented with several tactics, outlined below:

#### ***FLIR Monocular***

The Forward Looking Infrared (FLIR) Monocular uses thermal imaging that enables the pilot to see objects that emit heat (such as elephants) in low light conditions. The monocular is worn over one eye, enabling the pilot to see with normal vision out of the alternate eye. This method was successful in being able to see both the UAV and

simulated elephants. However, the gear is too expensive for widespread use, so other more affordable options will need to be considered.

#### *Torch attached to UAV for FPV*

Duct tape was used to secure a torch onto a UAV, with the light beam pointing straight ahead at the same angle as the camera. The field of view created by the light (400 lumens) was not large enough to make the First Person Viewer (FPV) usable. Stronger torches exist, but are too heavy to attach to the UAV.

#### *Torch attached at downward angle, coupled with second UAV*

The same torch was attached at a downward angle, and the UAV flew higher up to spotlight the simulated elephant and any obstacles, while a second UAV flew closer to the ground and employed the sweeping maneuvers to move the “elephants”.

#### *Torch on the ground*

A military-grade torch (lumens unknown) was used to spotlight the farm, and a UAV flew lower down to move the elephants. If torches of this caliber can be obtained, similar to what Honeyguide uses for their HEC missions, then this is the most attractive cheap option. The torch was powerful enough to find the “elephants” and any potential obstacles in a large field from a far distance, and then follow as the “elephants” were moved with the UAV.

#### *Best Practices for Night Missions*

Effective night tactics might include carrying out broad sweeps that are increasingly further and further from the pilot that will herd elephants away from the operator across a broad front. This may be particularly effective if elephants begin to associate the UAV with chili powder (diffuse clouds dropped from roughly 20m so as not to panic the animals from strong doses of irritant) and strobelights. If elephants can be ‘trained’ to associate UAV noise and lights with chili-powder and strobe lights then the efficacy of night operations may be greatly enhanced, and perhaps chili powder may not have to be used in the future.

#### **UAV Flight Profiles**

The Phantom Vision model carries a longer battery life. However, the battery is limited to 300 cycles, and runs at ~140 USD, compared to ~25 USD for the older TX60 batteries for the FC40. Our prior assumption that maneuverability is the most important specification was somewhat disproven, as elephants were shown to move even when the UAV was relatively far away from them. Given this, slight differences in maneuverability are not as important as previously thought—elephants have been successfully herded with the newest versions of the Phantom vision. That being said, in an emergency situation and in close quarters the added maneuverability of the FC40 may make the difference in effective and safe herding or diverting animals away from people or communities.

#### **Safety Considerations**

No injuries to people or elephants were sustained in this training. The trainers spent considerable time teaching safety protocols and airspace guidelines to the rangers, including assessing the flight situation prior to takeoff, landing if aircraft are heard or seen, not flying above 100 feet, landing if birds of prey are interacting with the UAV, avoiding obstacles, people, and homesteads at risk, asking farmers and local people the safest and best direction to move elephants prior to deployment if they are present, keeping the UAV in-between people and elephants, and not harassing young elephants.

Three situations in future trainings must be carefully addressed to avoid safety incidents:

- 1) One is the need for careful deployment and management of chili powder on the UAVs and in the vehicles. Chili powder disperses easily into the air and onto clothing and onto people handling the equipment; if not properly handled and contained, incautious releases of UAVs can injure or cause serious discomfort to operators and bystanders. Bottles of water for flushing people's eyes should be kept in the trucks as an essential part of the toolkit.
- 2) The second is the release and catching of the UAV by the co-pilot in the moving vehicles. The release must occur after the motors have gained sufficient power to lift the UAV straight up. Releasing it early may cause the UAV to slide downwards and backwards into the truck, potentially injuring personnel. The pilot and co-pilot must communicate well on this, and the pilots must watch the UAVs throughout the mission, not face forward in the moving vehicle all the time, unless tracking the UAV on a tablet video. Catching the UAV should be done with caution. Carefully bringing the UAV down and then allowing the co-pilot to get underneath is the best option, rather than flying directly at the co-pilot.
- 3) The third situation, one of great importance, is *ensuring that the pilots have sufficient skill to continuously herd the elephants away from the operator and other people*. Their herding skills must be such that they maintain pressure, at close distance (but not too close as to hit obstacles or be swatted by a trunk), to keep up the motivation and action of the elephants to move away from the vehicles, people, communities, and farms. Poor piloting skills, interruption in herding pressure, or other actions that may lead to elephants turning back or towards people can result in injury or death from aggravated and frightened elephants. This is a key consideration.

### **Airspace Guidelines**

The Tanzanian Civil Aviation Authority representative said that as long as operations were under about 100 feet (33 m) and pilots always landed the UAV if airplanes or other aircraft were seen, heard, or suspected of being in operation nearby, then use of UAVs for HEC mitigation was not an aviation concern at this point. Pilots have no need to ever go above 100 ft and should be trained to avoid this action. Rangers should also alert local airstrips and operators of their use of UAVs and their safety protocols. For example, an ultralight for wildlife surveys was in operation at an airstrip near the training site at Tarangire and was informed of UAV mitigation and training activity. The importance of following the user guidelines was stressed during the training and it was highlighted that the future policies for UAV use could be shaped by this program.

### ***Experienced & Skilled Trainers are Essential***

Marc Goss and his MEP rangers were excellent teachers and led the training very well. Looking ahead to future trainings with Tanzanian partners and perhaps with the Kenya Wildlife Service and wildlife managers in Nepal. We strongly recommend that experienced trainers should take the lead in future training courses as they know all aspects of UAV operation and maintenance, elephant behavior, and herding tactics. Our present team easily has the most experience in herding with UAVs in the world, and have an excellent rapport with rangers. A Nepal training will require someone in an organizational role, such as BWS's Eric Wikramanayake, who can bring key wildlife, aviation, and community officials to the workshop and remain in a supportive role after the training. There should also be an effort to bring more women wildlife managers and officials to these trainings.

### ***Further Training is Essential for Success***

Our Tanzanian partners have requested that further trainings occur in the near future, either by some of the partnership staff training some 'ace' pilots in the field, having a liaison in the field while conducting operations for a certain period of time, or having some rangers visit the Mara Elephant Project camp for further training in the near future. However, the goal is to have Tanzanian rangers train other rangers over time.

### ***Best Practices***

We did not use chili flakes with seeds in the training as TANAPA cautioned that chili seeds strewn on the landscape may have the potential to turn into an invasive species. This is a good best practice—powder and dry grass to attain the proper texture likely work adequately. A mixture of powder and coarser material is essential, however, to ensure an even release of chili powder sustained over a period of time.

We continue to experiment with plastic bag and coffee filter release of chili.

We also covered best practices for interacting with elephants—elephants should never be touched or injured by the UAVs; one should always avoid harassing young elephants, taking care not to drop chili powder near them, as distressed young elephants may make mother elephants act defensively, either creating chaos or attacking—both actions that do not help herding elephants in a particular direction—and creating a dangerous situation. Matriarch and mother elephants may be good to target to get the herds to move out in an organized way. A rapid, pronounced, and sustained (one cannot let off) 'harassment' seems to be important to move elephants effectively.

If elephants begin to associate UAVs with chili powder, they are likely to move just in response to the sound or sight of the UAVs; if this is the case then the use of chili releases should be curtailed, as a humane best practice. Given that this is the first training of its kind we need to ensure that the standards are set for responsible use of UAVs in Tanzania.

We remain uncertain as to whether or not rangers will need to fly with the elephants all the way back into parks or WMAs or if the animals will run back to the park following

initial deployment without being chased all the way. Elephants have been observed to stop their flight when the UAVs return to base, and it is uncertain if they will circle back to crops at this point.

## Debrief & Feedback Meeting Notes

1. Effective battery life
  - a. Participants asked for longer battery life, suggesting 1 hour to be ideal
  - b. Randy Braun (DJI) said that 1 hour was impossible at this point
    - i. Engineers actively working on this problem
  - c. It was decided that the easiest way to get around this now is having more batteries, multiple chargers, and quick battery or UAV exchanges
  - d. Elephants have moved quickly in field trials, meaning shorter flight times should be okay in the near future
  - e. Randy Braun (DJI) suggested having two UAVs in the vehicle, so that the second can be deployed while the first comes back for a battery change, keeping the pressure on at all times
    - i. Good idea, but cost may be prohibitive to use 2 UAVs for each mission
2. More UAVs, more practice
  - a. Rangers stressed the importance of getting more flying time
  - b. Wanted the UAVs to stay at the park so they could continue practicing
  - c. We need to consider how this will work when we establish a larger training program
    - i. How will participants be able to continue practicing after the training
    - ii. Exploring the use of flight simulators
3. Torch built into the UAV and consider the possibility of replacing existing lights in UAVs with strobe lights
4. DJI participants will “fight for more UAVs” for the program
  - a. Buy-back proposal being worked on
  - b. Bring in used and donated UAVs
  - c. Quantity discounts
5. Stick to the basics when flying (Randy Braun, DJI)
  - a. Advanced maneuvers for the obstacle courses are not necessary for moving elephants
  - b. Need to maintain UAVs through proper care and minimizing crashes
6. When should chili powder be implemented?
  - a. Combine with different approaches
  - b. Use it as part of escalation tactics – Kateto Ollekashe (Honeyguide)
    - i. Elephants will learn to associate the UAV with harsher deterrents and begin moving more easily
  - c. Need to consider how to implement in conjunction with chili fences
    - i. Need to know where existing fence lines are so that you don’t chase them into these
    - ii. Will require work and coordination with the community

7. Safety – Randy (DJI)
  - a. Catching and releasing must be done slowly
  - b. Allow the co-pilot to walking under hovering UAV and grab it, rather than flying the UAV to them (catching by hand and hand-launching UAVs minimizes dust from landing it or taking off from the ground).
  - c. It will not always be necessary or safe to deploy the UAV during HEC
    - i. Consider environment, surrounding, and situation at hand before deploying – if people are scattered throughout the field, do not fly
8. Possibility of waterproofing
  - a. Waterproof UAVs exist, but are expensive
  - b. Keep it dry → only fly in a light rain – Randy (DJI)
  - c. Operate remote controller through a bag to keep all water off of it
9. Responsibility of being the first to fly in Tanzania – Lucas (TAWIRI)
  - a. Don't break rules
  - b. Future of the program is dependent on rangers flying responsibly
  - c. Future laws on UAV use in Tanzania will be heavily dependent on how this program functions
10. Data sheets
  - a. Pilot, co-pilot, data collector, driver
  - b. Sheets will be given to the supervisor and will be sent to BWS for analysis
  - c. Important to fill these out and get them to the analysis teams
    - i. Help us understand what the best practices are
    - ii. will help validate program and raise support

## Appendix I. List of Participants

LIST OF PARTICIPANTS – TARANGIRE UAV FOLLOW UP TRAINING, 16 - 20<sup>th</sup> February, 2015

S/no	NAME	ORGANIZATION/TITLE
1	Alex Chang'a	WAP-Tanzania
2	Sue Palminteri	RESOLVE-USA
3	Teddy Kinyanjau	COOKSWELL JIKOS
4	David Olson	RESOLVE-BWS
5	Lucas Malugu	Tanzania Wildlife Research Institute
6	Marc Goss	Mara Elephant Project, Kenya
7	Dickson Njapit	Mara Elephant Project, Kenya
8	Steven Ekeno	Mara Elephant Project, Kenya
9	Angela Mwakatobe	Tanzania Wildlife Research Institute
10	Inyasi A. Lejora	Tanzania National Parks
11	Julius Keyyu	Tanzania Wildlife Research Institute
12	Nashon Macokecha	DGO-Babati District
13	Hezron Luhende	Ranger-Tarangire National Parks
14	Boniface Osujaki	WCS-Field Officer
15	Octavian Kabunazya	Ranger-Tarangire National Parks
16	Said Hewas	Game Warden –Babati District
17	Timotheo Delay	Village Game Scout-Burunge

18	Kateto F. Ollekashe	Honeyguide Foundation
19	Joseph Mpuki	Village Game Scout-Burunge
20	Jonas Peter	Honeyguide Foundation
21	Godfrey David Mmari	Ranger-Tanzania National Parks
22	Zawadi Mbwambo	Tanzania Wildlife Research Institute
23	Ole Meikasi	Outreach Officer–Tarangire National Park
24	Nathan Hahn	BWS-RESOLVE-USA
25	Nadia deSouza	BWS-RESOLVE-Kenya
26	Raphael Omondi	WAP-Kenya
27	Jonathan Konuche	WAP-Kenya
28	George Powell	RESOLVE-USA
29	Lori Price	RESOLVE-USA

## Appendix II. Practice Drills

### Basics

- Fly a straight line and box
  - Focus on straight flying to a point, or several points
  - No need to use the yaw, keep the UAV pointed forward and use the right stick to navigate and change direction
- Fly a circle
  - Use yaw to slowly turn the direction of the UAV while moving forward so that an even circle is created
- Quick stops
  - Fly quickly forward, and brake by pulling back on the right stick
  - This is good practice for getting into position to herd, and regaining position if you move too far to the side or in front of the elephants

### Advanced

- FPV basic
  - Fly the basic maneuvers using only the FPV camera
- FPV course
  - Set up a course that goes behind and inbetween trees so that it can only be flown safely using the FPV
- Obstacle course
  - Set up obstacle course using natural surroundings (under and through branches, around trees etc.)
  - Optional use of FPV, depending on the course
  - Make this competitive – it will add some fun to a long day, and is a good way to get the pilots to focus

### Applied

- Simulating elephants
  - Ranger stands 20m away and is instructed to move based on the position of the UAV – but it must be within a few meters before they start moving
  - Pilot must move the ranger back to a predetermined point
    - If the elephant is moved back, it's a success
    - If the elephant ends up next to the ranger, it's a failure, as this means the pilot didn't keep the UAV in-between him and the elephant
  - See footage of training to see this drill in action
- Simulating elephants (advanced)
  - Multiple rangers stand 20m away and follow the direction above
    - The group acts as a herd, and the pilot must use sweeping maneuvers to keep them together and move them back
  - We also tried using a second vehicle as an elephant, although this was too slow and didn't work well