The case for funding development of Airborne SAR Detection of Wildlife Snares

Why We Think Radar Will Work For Snare Detection:

- Radar is an active detection strategy, rather than passive like optical or thermal imagery. We are flooding the area with radio signals waiting for a ping back from a reflection.
- The receiver is extremely sensitive, able to pick up the smallest reflection off a metal surface.
- Metal is the most reflective material to radio waves 98% of snares are metal.
- Snares in wilderness areas are in areas where there is very little other metal.
- Snares in wilderness areas are in areas where there is very little radio frequency interference.
- Radar transmitting in the 2 GHz frequency range penetrates vegetation making it possible to detect snares in vegetation.
- Snares have a cylindrical geometry meaning that somewhere along the radius of the wire there will be reflection back to the transmitter.
- Snares by far are made of metal (98%), this is mainly so that animals can't chew their way out of snares, so that there are limits of poachers migrating to different snaring materials that are not picked up by radar.
- Our Synthetic Aperture Radar operates in 4 discrete polarizations, creating 4 channels of information that can be used in defining the signature of reflective targets - snares in this case.
- Synthetic Aperture Radar has been used to detect anti-personal mine trip wires of 0.5mm in diameter, albeit at a shorter range.
- Snares form a circle with one end attached to a grounded object, either a tree or log making them a simple antenna, a form optimized to interact with radio waves.
- Synthetic Aperture Radars resolution does not decline with distance. Therefore it has the same resolution over a swathe of 1km in width
- Synthetic Aperture Radar works at a flight speed of 72km/ (possibly up to 136km/hr) scanning a 1km width allowing it to thoroughly search huge areas.
- Our trials indicate that all the systems are working well, reliably and with repeatable results – The challenge is now to recognize those ping backs from the snares in this verry large noisy data stream.

Why We Think This Will Be A Game Changer In The Battle Against Snaring:

SAR has the potential to detect and accurately locate all snares in a large area independently of terrain.

Locating and removing snares at this scale can change the economics of poaching making it not worth poachers time setting snares which will detected and removed and with the higher risk of being caught by anti-poaching units deployed in the area to remove the snares.

The complete access and scale at which airborne SAR can operate allows us to cover whole reserves and conservation areas, avoiding the displacement of snaring activities in response to local targeted snare removal efforts and patrolling.

The ability to remove snares at scale will turn the strategy from a costly[1], punitive catch and punish poachers' strategy to making poaching unfeasible. No poacher is going to walk into a conservation area spending time and effort to set snares when there is an 80% chance the snares will be removed.

Detecting all snares timeously will save 100 of millions of wildlife lives (e.g. 13 million a year lost just in 5 East Asian conservation areas).

Removal of snares will address the greatest threat to wildlife in protected areas. (Loss of habitat is the biggest risk outside conservation areas, but snaring is the biggest risk in conserved areas. Snaring has led to the decline and extirpation of lions, leopards, cheetahs, hyenas, wild dogs in many areas as well as killing their prey and smaller animals).

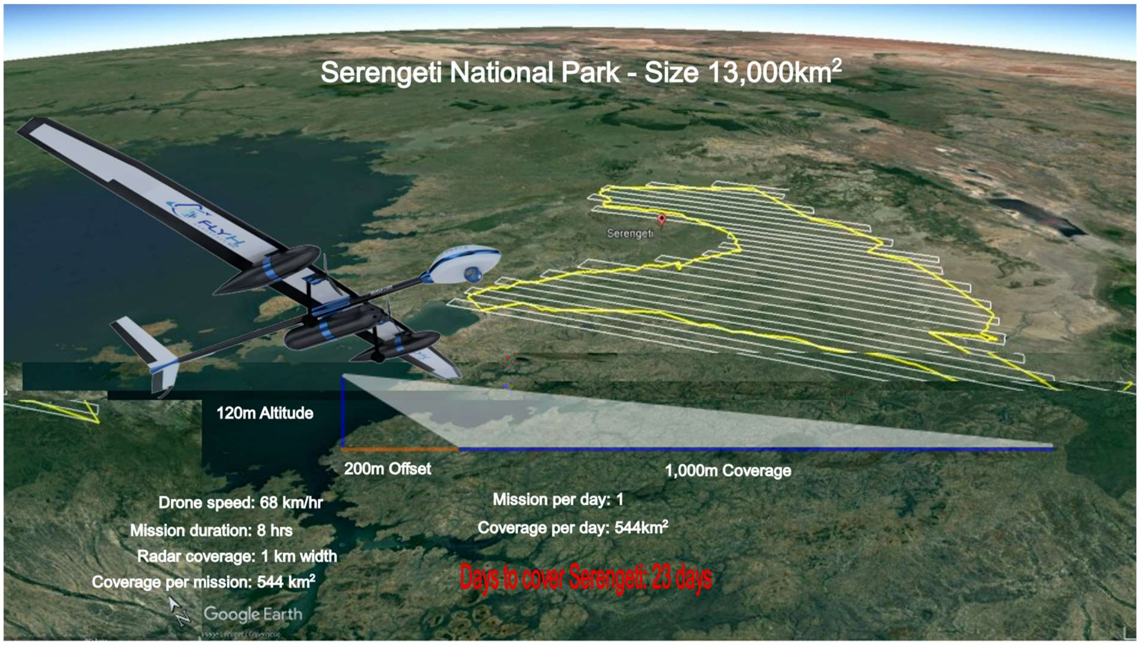
SAR gets rid of all snares, even snares that have been forgotten by poachers are the hardest to find and remain a risk to wildlife decades after they have been set.

SAR will free up ranger time from time consuming snare patrols to other targeted interventions.

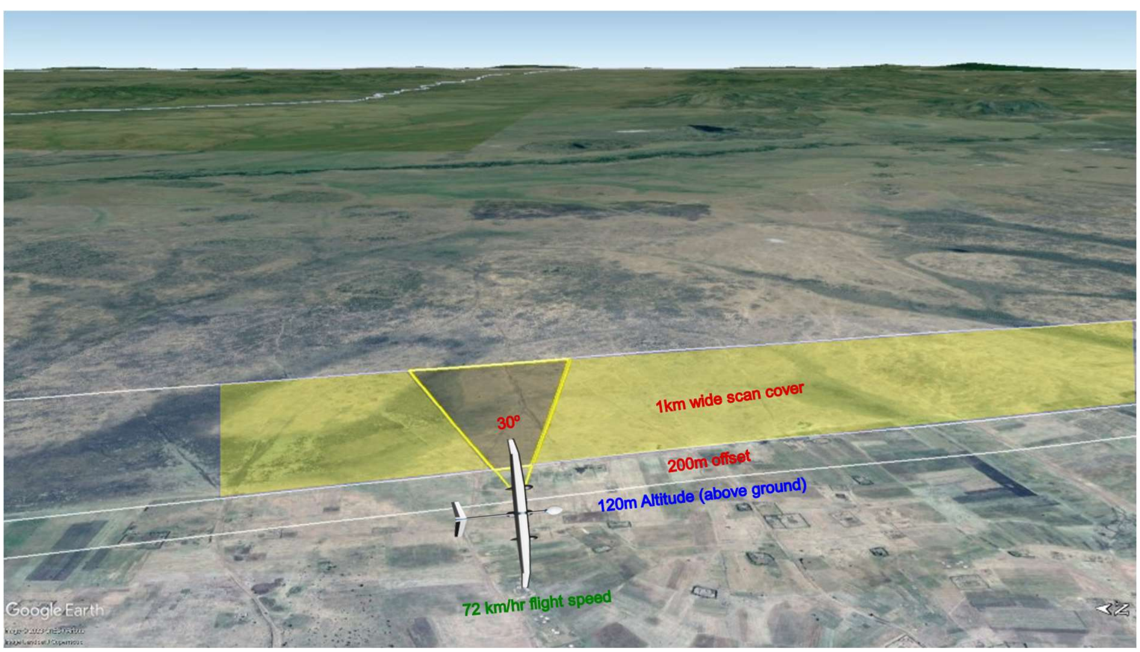
[1] Apprehending bushmeat poachers, getting them back to camp, getting a driver and the anti-poaching members to go to the local police station to lay a charge and make statements followed by court hearings, just consume scarce conservation resources - manpower, vehicle availability, fuel, time, and management attention, often too little effect. Cases are dropped because of lack of evidence, judges don't appear, defendants don't appear sentences are often so light as not to be a deterrent.

How the system will work:

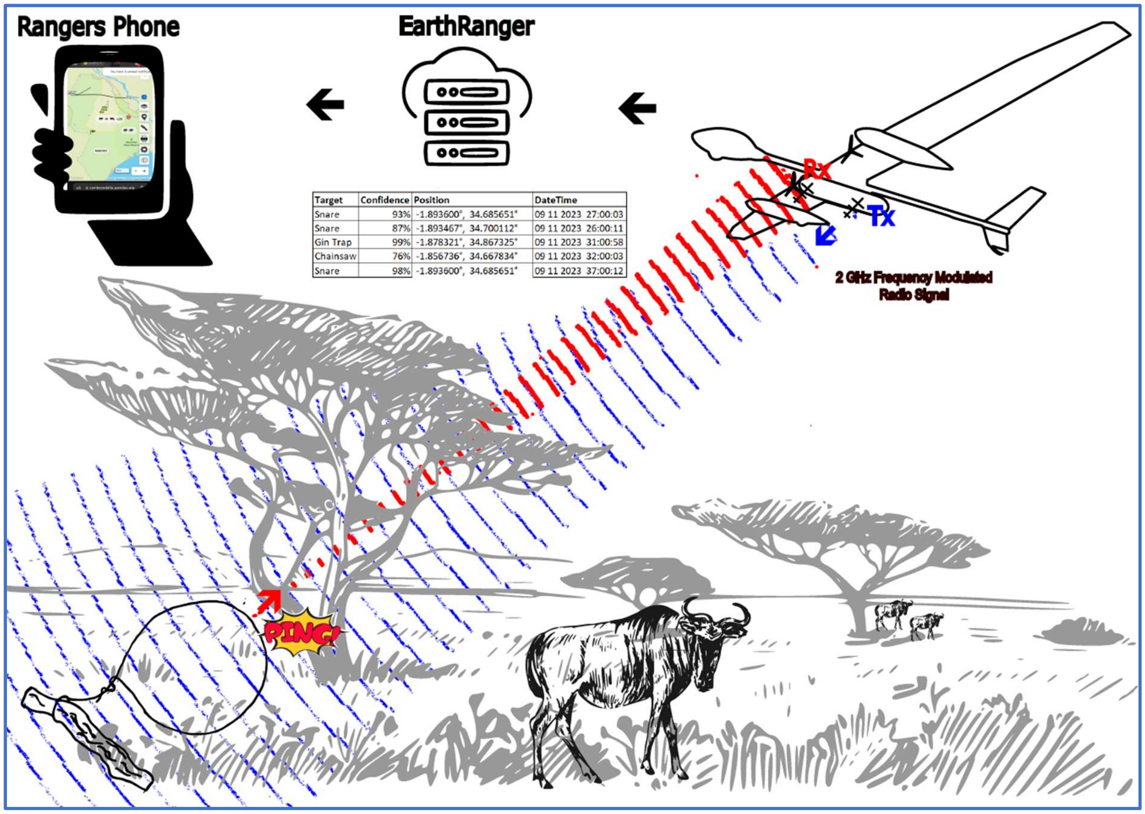
- Long-endurance drone will take off from parks headquarters flying a predefined mission surveying the whole reserve and returning to headquarters.



- It will fly at 120m above ground level and scan a 1km wide swath at 72km/hr.
- It will transmit a frequency modulated radio signal in the 2GHz range that propagates at 30º to the transmitting antenna (Tx).



- At 2 GHz the radio signal can penetrate clouds, rain and vegetation and the operation can be done at night when there is little on the ground and aircraft activity.
- The sensitive receiving antenna (Rx) picks up any reflection of the of the signal.
- The position of the reflecting target is determined by the time difference between the propagation of the signal and reception of its reflection, giving the distance to the target, and doppler shift of the signal due to the 72km/hr forward motion of the drone that gives the angle to target.



- The position of the drone and antennas is recorded by a combination of Real Time Kinetic positioning (RTK) GPS positioning and an Intertial Navigation Systems (INS) systems on the drone .
- The system allows a < 1m accuracy of the location of the target.
- Information on the type of target is given by the amplitude of the reflected wave and how it interacts in the 4 radio wave polarization channels.
- This data is recorded and uploaded to the cloud where it is analyzed, and potential targets are recorded as follows:

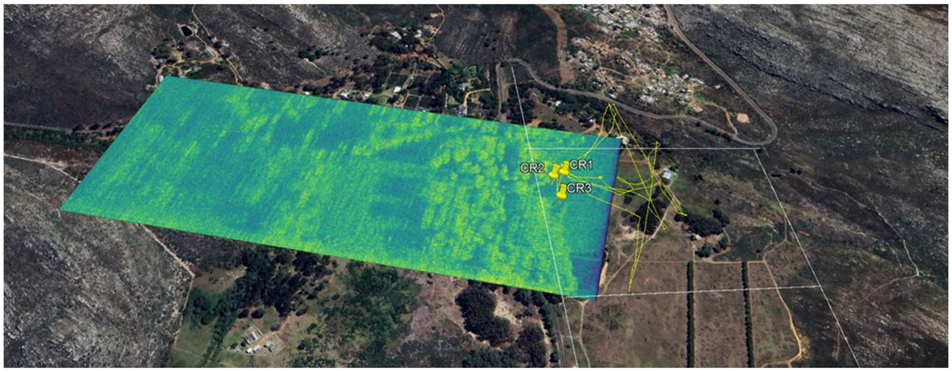
Target	Confidence	Position	DateTime
Snare	93%	-1.893600°, 34.685651°	09 11 2023 27:00:03
Snare	87%	-1.893467°, 34.700112°	09 11 2023 26:00:11
Gin Trap	99%	-1.878321°, 34.867325°	09 11 2023 31:00:58
Chainsaw	76%	-1.856736°, 34.667834°	09 11 2023 32:00:03
Snare	98%	-1.893600°, 34.685651°	09 11 2023 37:00:12
Firearm	46%	-1.926832°, 34.670006°	10 11 2023 39:32:03

- The Confidence column reflects the reliability of identification of the target

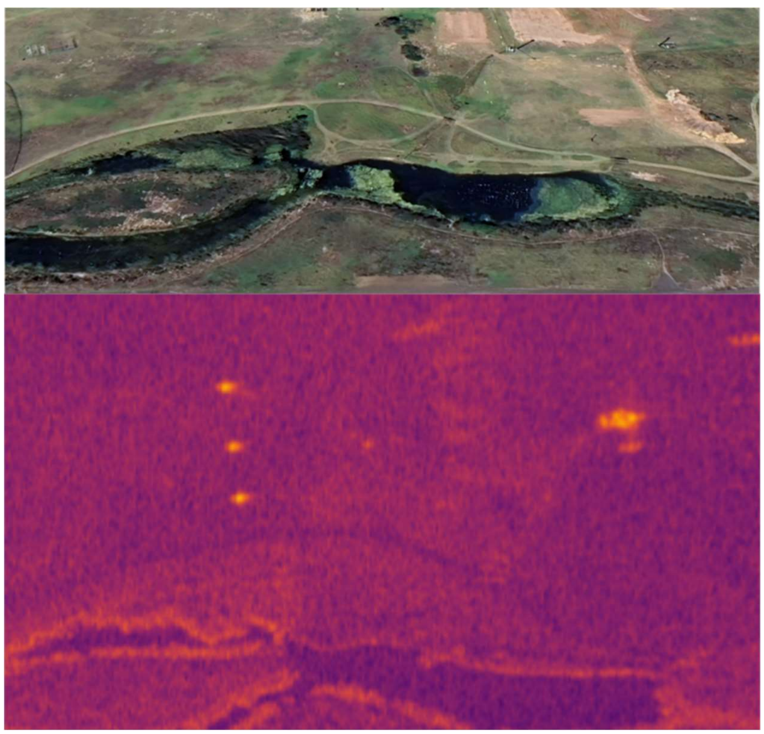
- Target identification can additionally include motor car, motor bike, bicycle, pot (basically anything metal).
- The data will be ported to via EarthRanger to the reserve control room screen and antipoaching units for as mapped alerts for actioning.
- An algorithm will be implemented to avoid any false positives, essential to keep reserves responding to these alerts. False positive alerts where rangers go out and there are no snares will result in lack of confidence in the system and lead to APU teams not responding to all alerts.

How far have we come?

- Completed 3 self-funded field trials with borrowed drone.
- SAR working and scanning a 1km strip parallel to flight at 120m above ground level



- Picking up reflective targets without any modification and basic filtering.



- We are confident that the system is working reliably and consistently.

What we need now?

1. Funding for an electrical engineer to further process the data that we have now
2. Funding for a suitable drone (or drone hire)
3. Funding for 6, 5 day field trials 5 trials
4. Funding for a month's analysis of each of the field trial by an electrical engineer
5. Funding for 1 month writing up of report
6. Project management salary 6mnths

Currently the data is being processed Kevin who has a day job as SARs System Engineer for Dragonfly Aerospace, is registered for a PhD and supports the provides support for the 2 drone units supplied to University of North Carolina and Purdue university.

We need to accurately register images flown with the snares and gin traps with images flown without the snares and gin traps.

Once this is done, we can filter the data by taking the Delta of the two images. It is a technique of taking out the background noise.

This will remove all reflections that have not changed between flights and give us a clearer image to characterize the signal of the snares and gin traps, to find how it is differentiated from the surrounding "pixels. (we marked the position and orientation of the snares and gin traps to sub cm accuracy with a differential gps).

There is a lot of manual cleaning processing to make sure the images and the gps positions register completely accurately in these trials.

We then need to use this data to characterize the signal of the snares and gin traps in terms of their interactions in the 4 different radio wave polarizations'.

If the initial flight data are good enough we then need to fly another trial with a suitable drone and test whether the signals are replicable.

The data from the trials might not be good enough because the drone we were able to borrow on all 3 trials (from the filming industry) did not have RTK and INS positioning, they also had to be flown manually rather on a waypoint mission and the RADAR could not be remotely triggered to start at a specified way point. These all effect the accuracy of locating the signals in space and really hamper analysis. They were also flown in poor weather windows (when film crews did not want to film) with rain and winds nearing the 9m/s threshold for drone flight. These weather constraints will be relaxed on the final aerial platforms.

If the initial flight data are not good enough we will have to redo the trials using a properly specified drone with RTK and INS positioning, remote mission planning and RADAR switching at a rural site in a good weather window over several days, with enough time to have a look at the data before flying repeat missions.

We will then have to process the data for each run accurately geolocating it. Then we will have to process the data to register the images and filter by subtraction (Delta) also play by filtering on other signal parameters. Then characterize the "pixel" where the snare or gin traps occur in comparison to neighboring "pixels". We then have to check whether we can filter and detect the targe signals in a single pass.

If successful we have to do another field trial to test whether we can detect target signals characterized in previous trial

We might have to do this over several iterations varying frequency modulation of the radar, flying height flying distance tweaking transmission and reception antennas etc.

Collaborators Biography

Michael Inggs: (Life Senior Member, IEEE) was born in the Eastern Cape, South Africa. He received the Honours degree in physics and applied mathematics from Rhodes University, Grahamstown, South Africa, in 1973, and the Ph.D. DIC degree in millimeter wave propagation through clear but turbulent atmosphere from Imperial College, London, U.K., in 1979.,He has worked in industry in the U.K., USA, and South Africa, and joined the Department of Electrical Engineering, University of Cape Town, Cape Town, South Africa, in 1988, from where he retired in 2016 as Emeritus Professor. His research interests include radar sensor networks, radar remote sensing with SAR, and high performance computing. He has published 174 peer-reviewed papers and is holder of several patents for his work.

Kevin Gema: Is a spacecraft systems engineer at Dragonfly Aerospace. He received his BSc in electrical engineering at the University of Pretoria and his Masters degree in Radar and Electronic defense from the University of Cape Town. He has held positions of electronic engineer at BAE systems, team leader software systems and system engineer for SAR imaging solutions for Space Advisory Company and is currently SAR Systems engineer at Dragonfly Aerospace. He has just registered for a PhD on developing and testing SAR for snare detection.