

An aerial photograph of a suburban neighborhood, showing a grid of streets and numerous houses with varying roof colors. The image is overlaid with a gradient that transitions from a bright green on the left to a deep blue on the right, creating a semi-transparent effect over the landscape.

November Drone Mapping Campaign in the Copperbelt

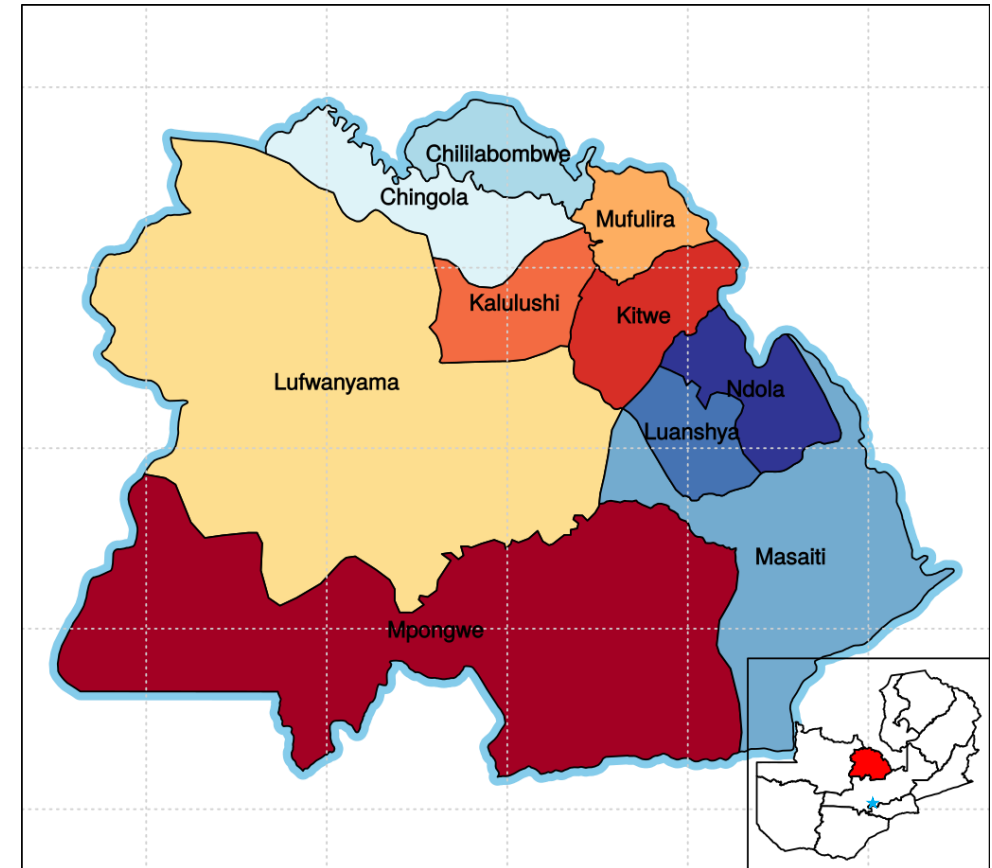
Ben White, Nick Kiraly, Martin Buchert
December 17th, 2020

Overview

- Pre-Campaign Research
- A day in the life of the Drone Team
- Post Campaign Analysis
- Campaign Challenges
- Scenes from the field

Copperbelt Province

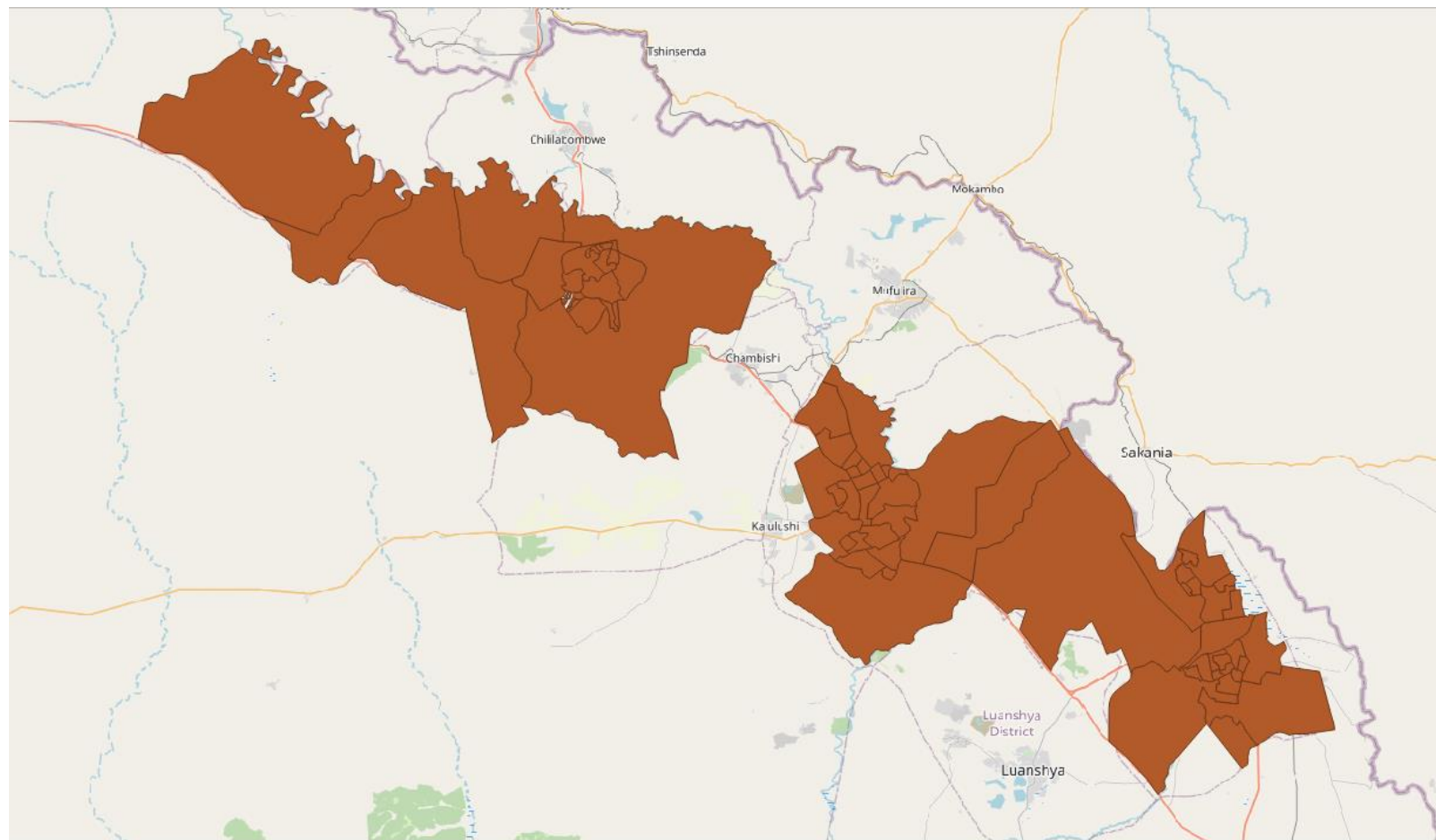
- 31,328 sqkm
- Population 2.3 million (2014)
- Mean Elev: 3,990 ft AMSL
- Capital: Ndola
- Bemba predominantly spoken (vs. Nyanja in Lusaka)



Districts of Copperbelt Province, Zambia

Initial AOI from Mr. Tembo

- 3 Cities: Chingola, Kitwe, Ndola
- 74 Wards
- 3,505.58 km²
(20.1x the island of St. Kitts,
87% of Rhode Island)
- Total Est. Population: 1,244,660

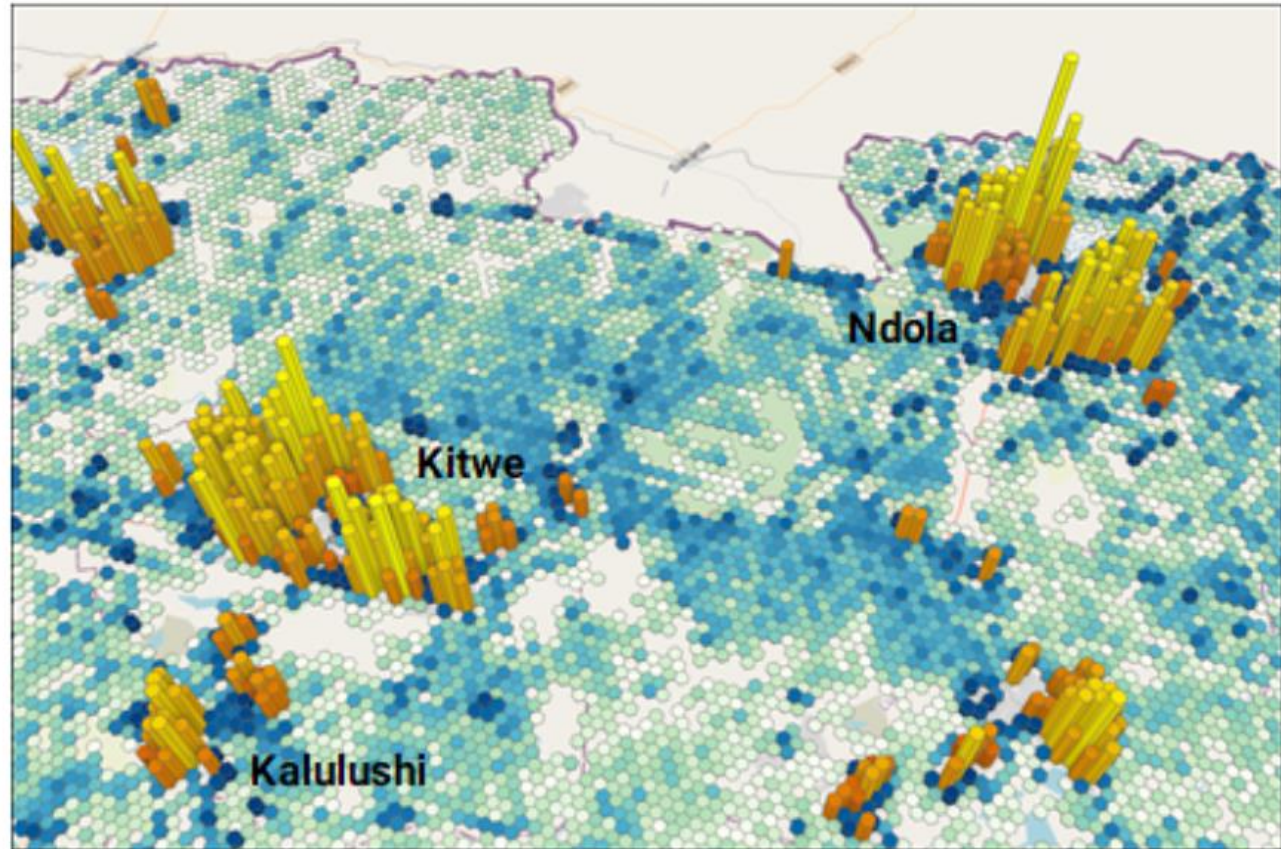


TAME to Maximize Parcels in Short Flight Campaign

Oct/Nov Campaign will focus on Kitwe & Ndola regions

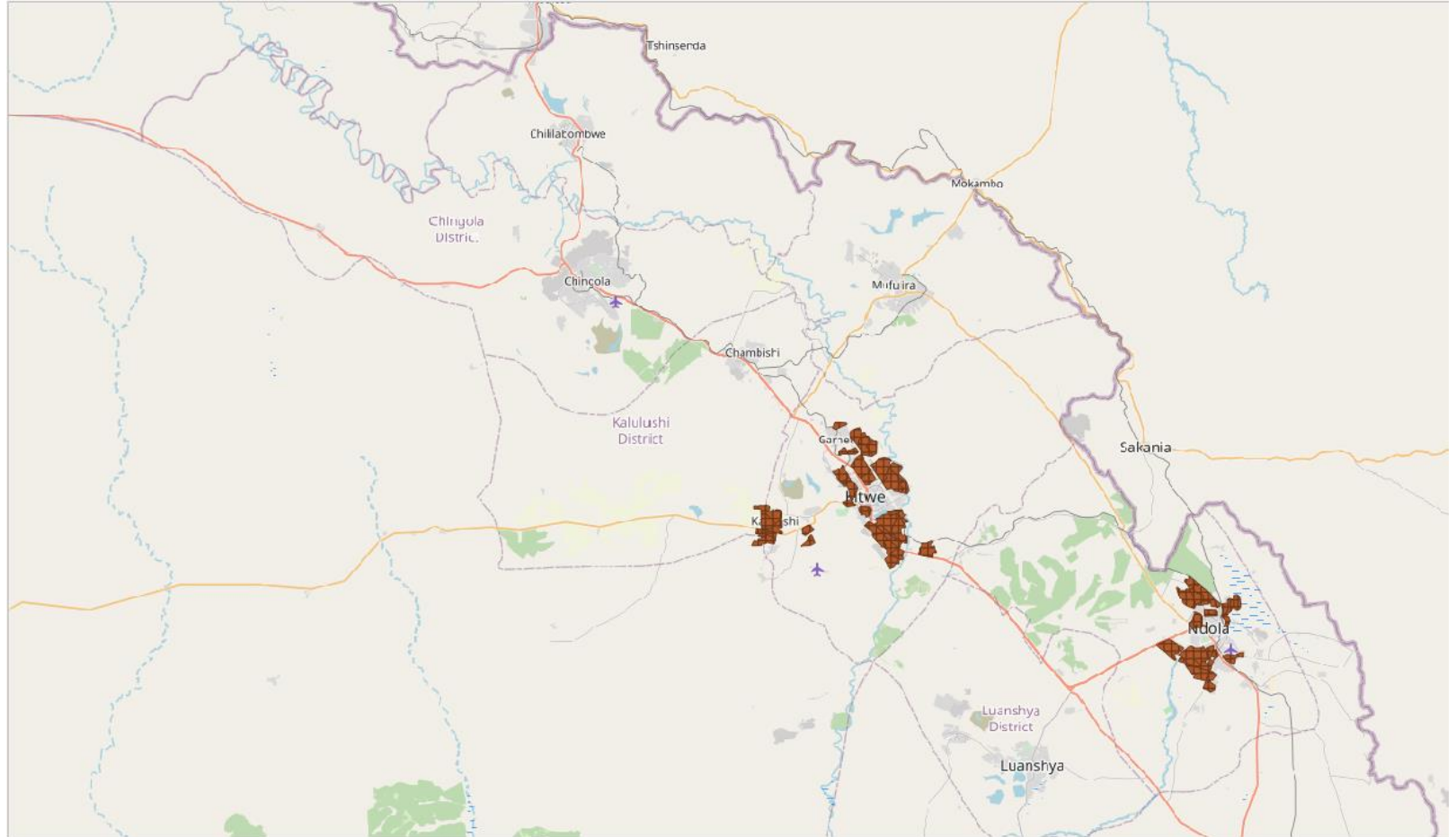
Volume of extruded hexes is proportional with #parcels

Kitwe (plus nearby Kalulushi) and Ndola represent the dominant fraction of predicted parcels in the region.

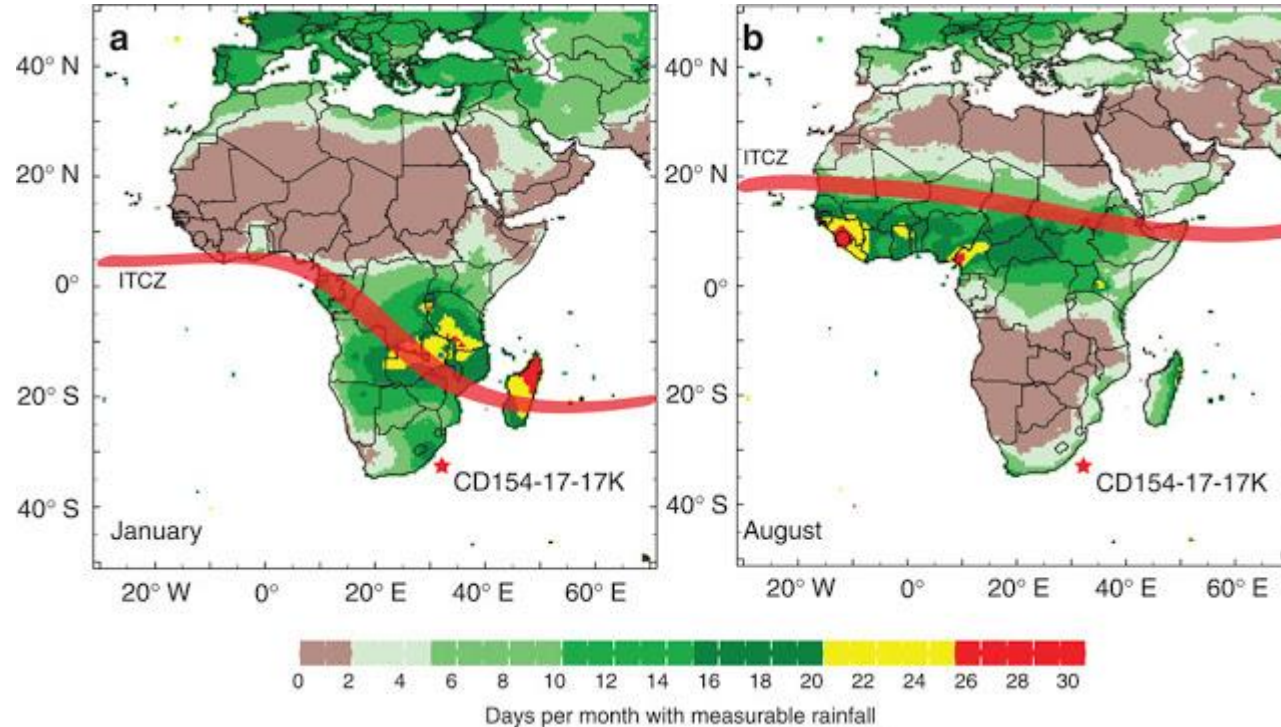


Aiming High...with Focused AOI

- 128.5 km² (81.4% of St. Kitts) of Kitwe and Ndola (No Chingola this time)
- Aggressive 19 flight-ops day campaign (70.4% of total 27 flight days of St. Kitts)
- Two VTOL Wingtra teams + potential 3rd eBeeX with MLG-Z Drone Team
- GNSS surveying of image checkpoints, monumenting
- 300+ potential launch points identified

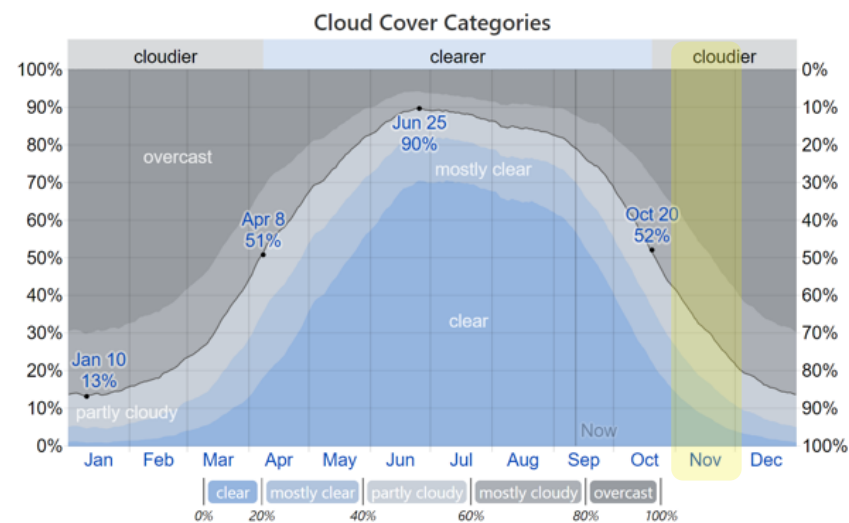


Pre-Campaign Research: Rainy Season or Bust

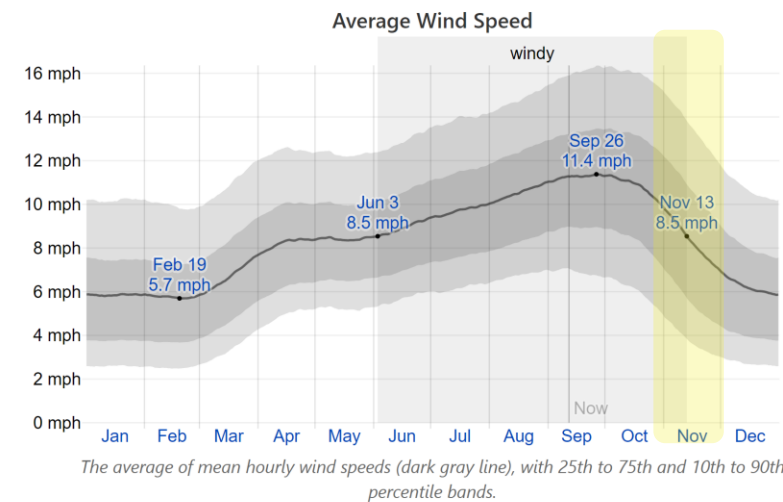


- Intertropical Convergence Zone migrating south as we move into winter
- ITCZ is associated with heavy rainfall
- Rainfall variability over Africa in (a) January and (b) August. The color bar indicates days per month with measurable rainfall.

Pre-Campaign Research: Rainy Season or Bust



The percentage of time spent in each cloud cover band, categorized by the percentage of the sky covered by clouds.



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

2020/2021 RAINY SEASON FORECAST MAPS

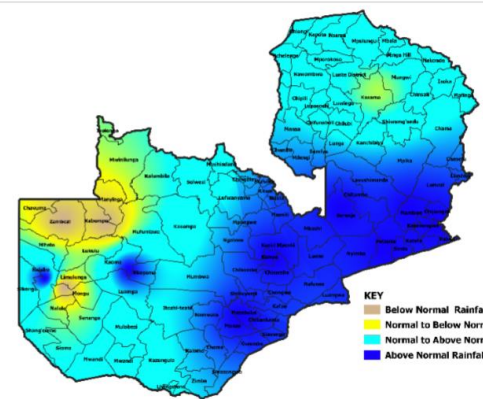


Figure 1: Rainfall Forecast for October, November & December 2020 (OND).

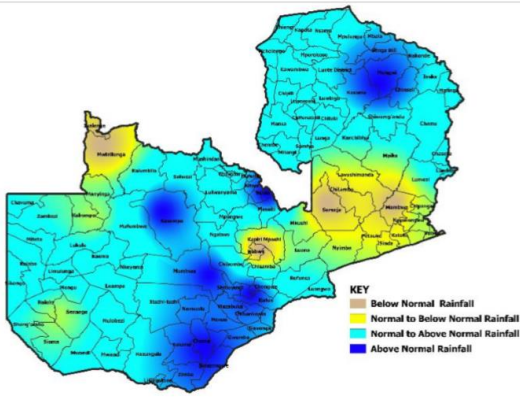
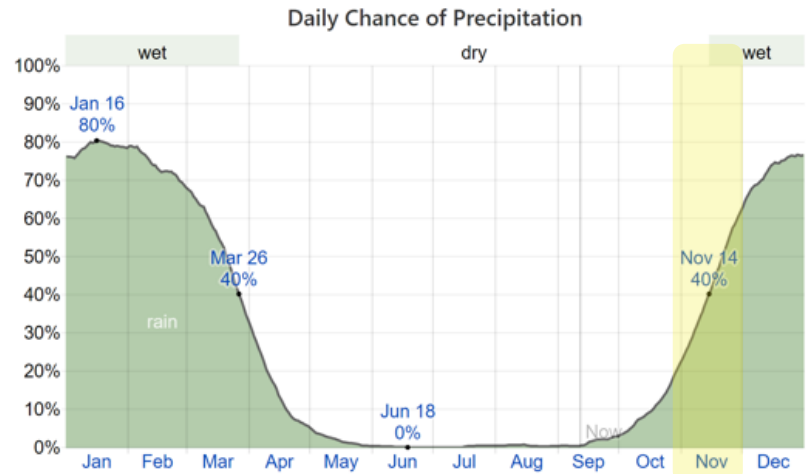


Figure 2: Rainfall Forecast for November, December 2020 & January 2021 (NDJ).



The percentage of days in which various types of precipitation are observed, excluding trace quantities: rain alone, snow alone, and mixed (both rain and snow fell in the same day).

More Pre-Campaign Research



U.S. Embassy in Zambia

VisasU.S. Citizen ServicesOur RelationshipBusinessEducation & CultureEmbassy

Security Alert: U.S. Embassy Lusaka, Zambia – January 24, 2020

Home / News & Events / Security Alert: U.S. Embassy Lusaka, Zambia – January 24, 2020



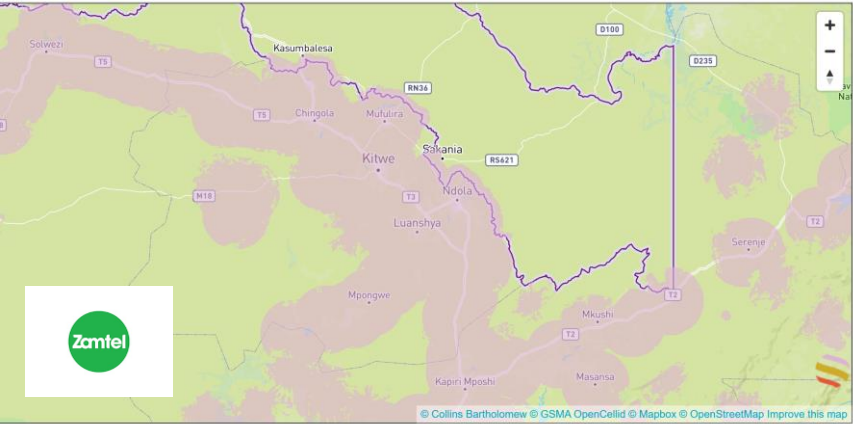
Location: Civil unrest in, but not limited to, Chingola and Kitwe, Copperbelt Province.

Event: Rumors of ritual killings in the Copperbelt Province have led to a series of riots in Chingola and Kitwe towns. The provincial government deployed additional police to both areas and imposed a curfew in Chingola to restore order. The situation on the ground remains calm but guarded. Rumors of ritual killings have spread in Solwezi, which have the potential to spark riots.

U.S. government personnel are prohibited from travel to Chingola until further notice, and are further advised to exercise increased caution while traveling in Kitwe and Solwezi.

Actions to Take:

- Avoid the areas of the demonstrations or riots.
- Exercise caution if unexpectedly in the vicinity of large gatherings or protests.
- Monitor local media for updates.
- Keep a low profile.



Index

Crime Index: 34.12

Safety Index: 65.88

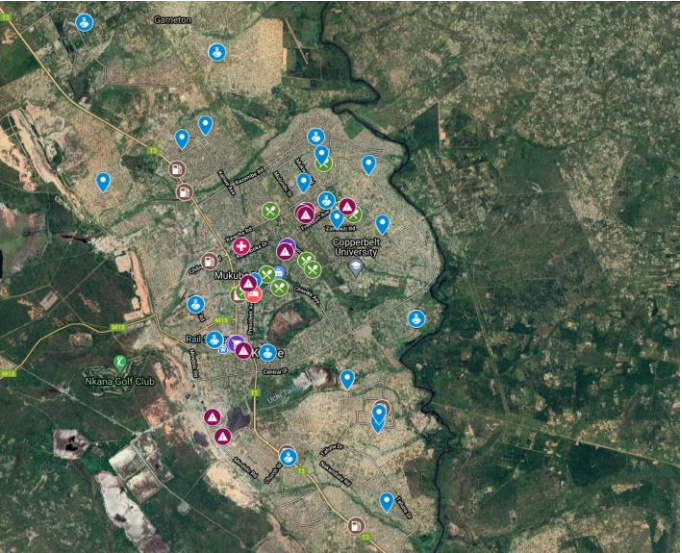
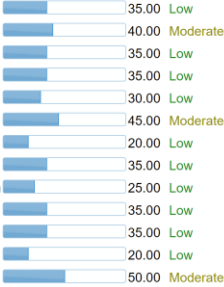


Crime rates in Kitwe, Zambia

- Level of crime
- Crime increasing in the past 3 years
- Worries home broken and things stolen
- Worries being mugged or robbed
- Worries car stolen
- Worries things from car stolen
- Worries attacked
- Worries being insulted
- Worries being subject to a physical attack because of your skin color, ethnic origin, gender or religion
- Problem people using or dealing drugs
- Problem property crimes such as vandalism and theft
- Problem violent crimes such as assault and armed robbery
- Problem corruption and bribery

Safety in Kitwe, Zambia

- Safety walking alone during daylight
- Safety walking alone during night



Equipment

- WingtraOne # 2062 (new!)
- TopCon HiperVR GNSS Base & Rover (new!)
- A fear of the global pandemic (new!)
- Wingtra #1804
- Wingtra pilot boxes
- eBeeX (backup)
- eBeeX spare wings
- Spare parts/field ops box
- senseFly GeoBase
- GNSS/surveying bipods
- Personal luggage



Campaign Team

FIELD OPS

GIS and Drones

- Martin Buchert
- Ben White
- Nick Kiraly
- CJ Sikasula
- Gerald Musonda

Communications

- Kwangu Liwewe
- Cisomo Zulu

Surveying & Accuracy

- Glenn Mwika

Local Staff

- Titus Chisha – Ndola Int'l Airport Sr. ATC Officer
- Obed – Kitwe City Council PR Unit
- Rotating Police Officers 1
- Rotating Police Officers 2

Drivers

- Jairos
- Joseph
- James

LUSAKA OFFICE SUPPORT

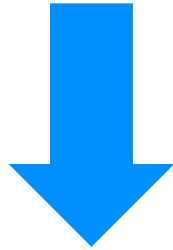
- Didier Sagashya
- Dorah Chisambi
- Lungowe Chintu

... and more!

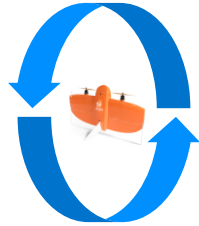
Some of the field team grabbing lunch nshima



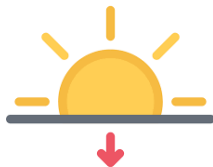
Rough Daily Schedule



- One driver-> Ndola and back to get ATC Officer
- Re-check weather reports/models
- Assess weather in local vicinity and on the horizon
- Breakfast,
- Pack equipment, load vehicles
- Get fuel, pick up police officers



- Setup base station, monument base station
- Flight plan, fly drones, charge batteries
- Sensitization
- Interviews/media
- Drive back to hotel



- Errands
- Post field meetings
- Charge drone and GeoBase batteries
- Visually inspect individual flight images
- Copy data to hard drive
- Convert GeoBase files: .SBF to RINEX
- Upload RINEX files to AUSPOS for absolute accuracy correction
- Post-process raw images
- Mission plan for the following day
- Dinner
- Additional MLG-SLC Meetings/Slack/Emails
- Produce daily update report to MLG

Campaign Sensitization



MLG Radio Advertisement (played on local radio stations and @ flight ops)

Lodging: Garden Court Kitwe



Tracking Flight Progress

Copperbelt Drone Mission Tracker

File Edit View Insert Format Data Tools Add-ons Help

Last edit was seconds ago

fx | Nick

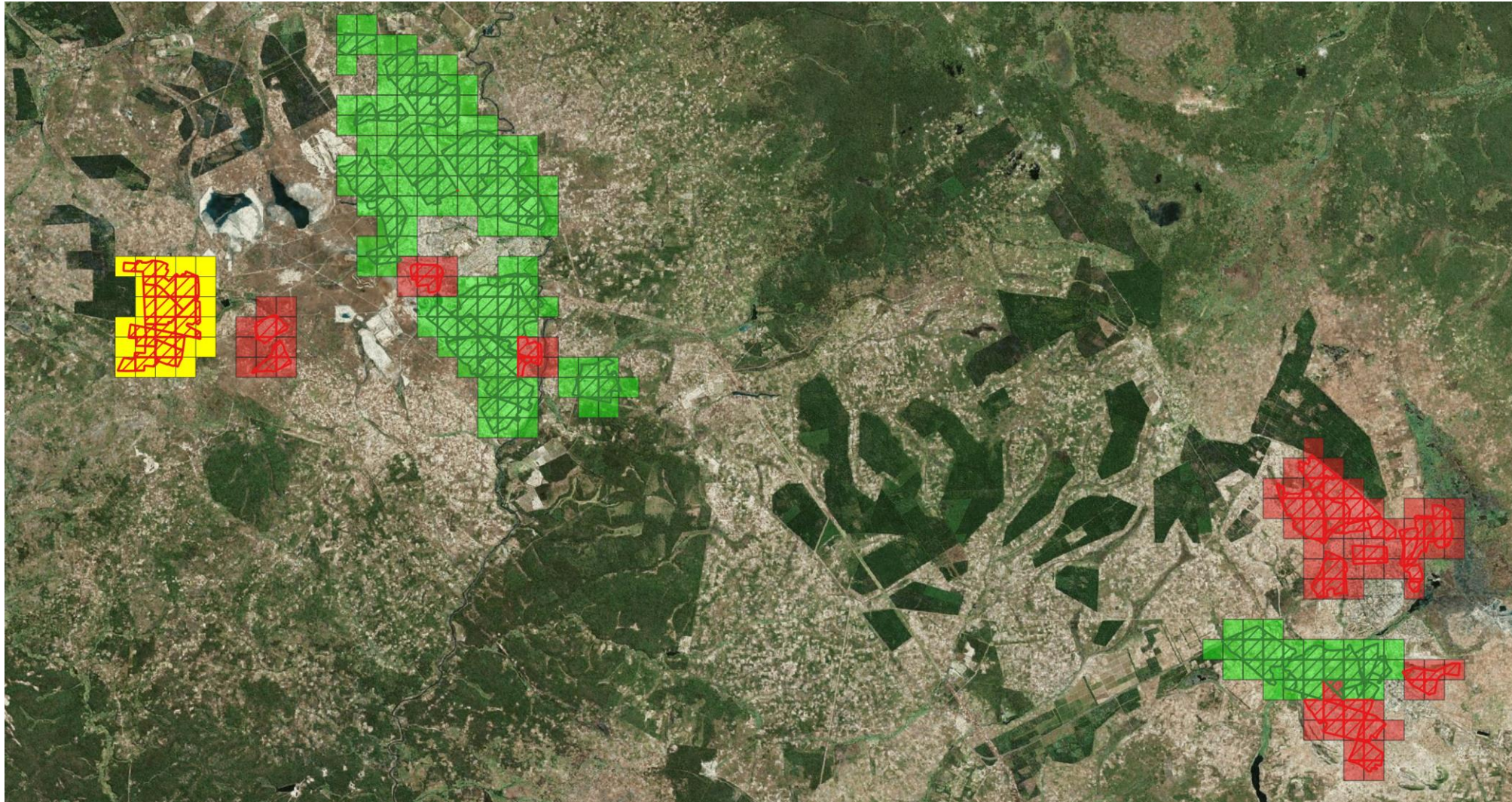
	A	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Flight_Plan	Full_Grids_Flowen	Grid1	Grid2	Grid3	Grid4	Grid5	Grid6	Grid7	Grid8	Grid9	Partial_Grids_Flowen	PartialGrid1	PartialGrid2	PartialGrid3	Sq_km_Flowen	Flight_Distance_km	Flight_Time_hms	Total_Area_ha	Images	Drone_Serial_Num	Screenshot	AUS
27	20201113_0911_CB_157_121	4	CB_156_122	CB_156_121	CB_157_122	CB_157_121						0				1.74	32.33	0:32:42	173.59	620	1804	Screenshot_20201115-090724	sflor
28	20201113_0933_CB_158_121	1	CB_158_121									1	CB_159_121			1.85	36.05	0:36:13	184.79	642	2062	Screenshot_20201115-080042	sflor
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30	20201113_1214_CB_160_121	5	CB_160_122	CB_161_122	CB_162_122	CB_160_121	CB_161_121					2	CB_159_121	CB_160_123		5.04	93.6	1:33:00	504.36	1852	2062	Screenshot_20201115-080245	sflor
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34	20201115_1007_CB_202_104	2	CB_202_105	CB_202_104								0				1.75	30.89	0:31:09	175.2	619	1804	Screenshot_20201115-161847	sflor
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44	20201117_1021_159_117	2	CB_159_117	CB_159_11																			

[illegible]

<https://www.google.com/maps/d/u/0/edit?hl=en&mid=1lcL41TtvoDESlo1euRWs0mKSK9Ra-nea&ll=-12.797995007935597%2C28.105476283341435&z=12>




MEDICI LAND GOVERNANCE

November Copperbelt Flight Campaign Final Update: 18 Nov 2020



Only the portion of the AOI within a 1sqkm grid is flown and not the full 1sqkm mission grid itself.
A grid is considered 'flown' if all discontinuous portions of the AOI within it are fully imaged.

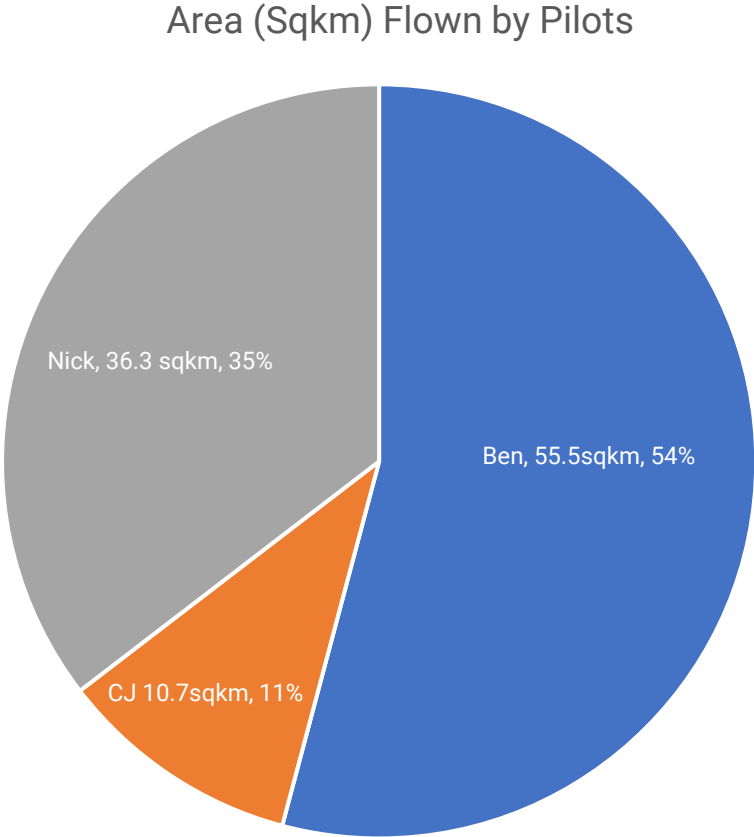
The majority of Kalulushi (yellow) was identified as being previously titled in the Cadastre Index as of 11/17/20

-  Area of Interest (AOI)
-  Flown Areas
-  Unflown Areas

**MEDICI LAND
GOVERNANCE**

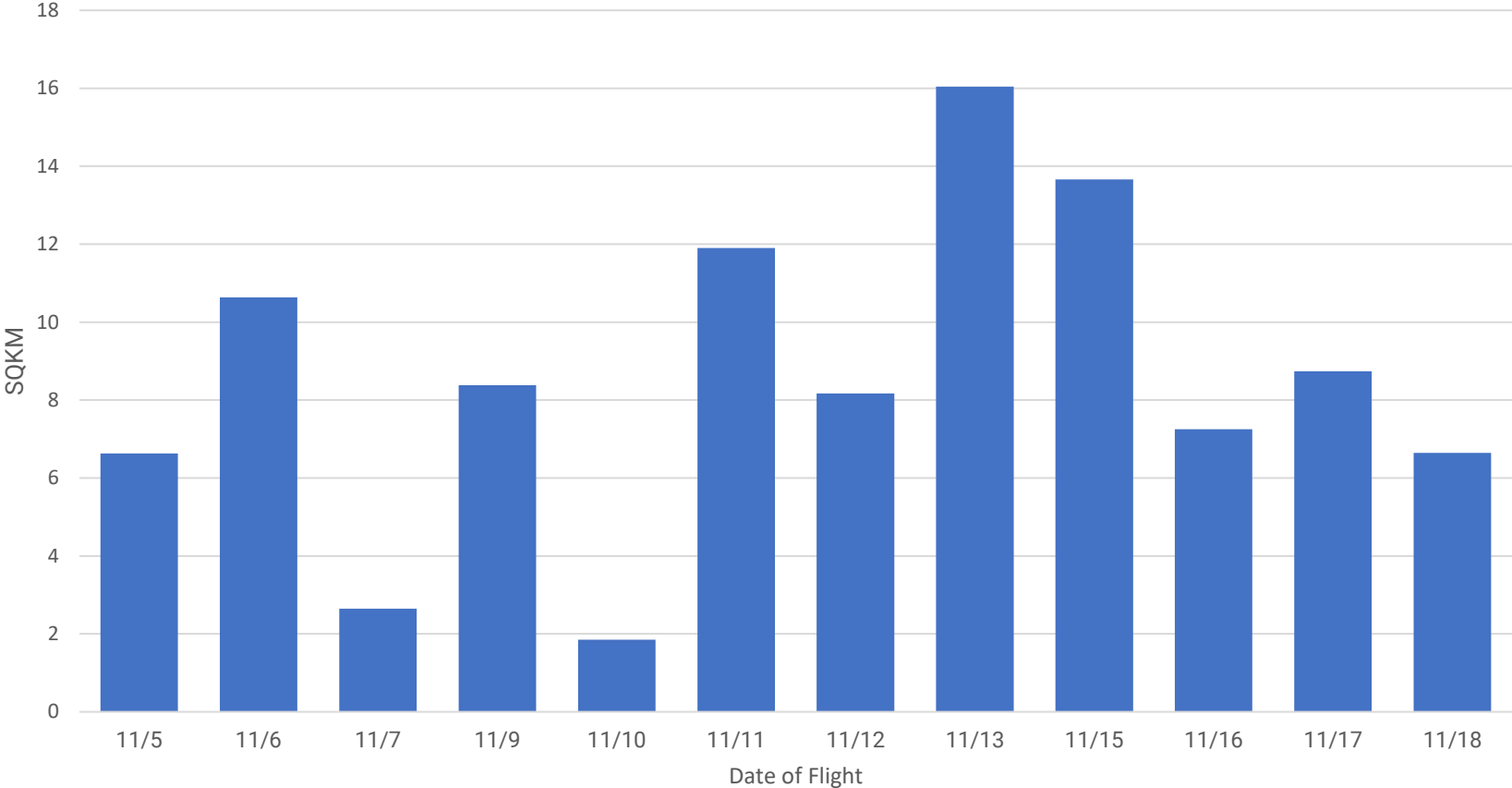
Campaign Statistics

Statistic	#
Number of flights	68
Number of flight ops days	12
Total Flying Time	31:13:57
Total area flown (km ²)*	102.6
Total AOI area flown (km ²)*	78.9
Number of raw images	36,249
Linear distance flown (km)	1,862.6
Number of launch sites	18
Number of pilots	3
Average Workday Length (hrs)	16
# consecutive campaign workdays	28
# of campaign days off	0



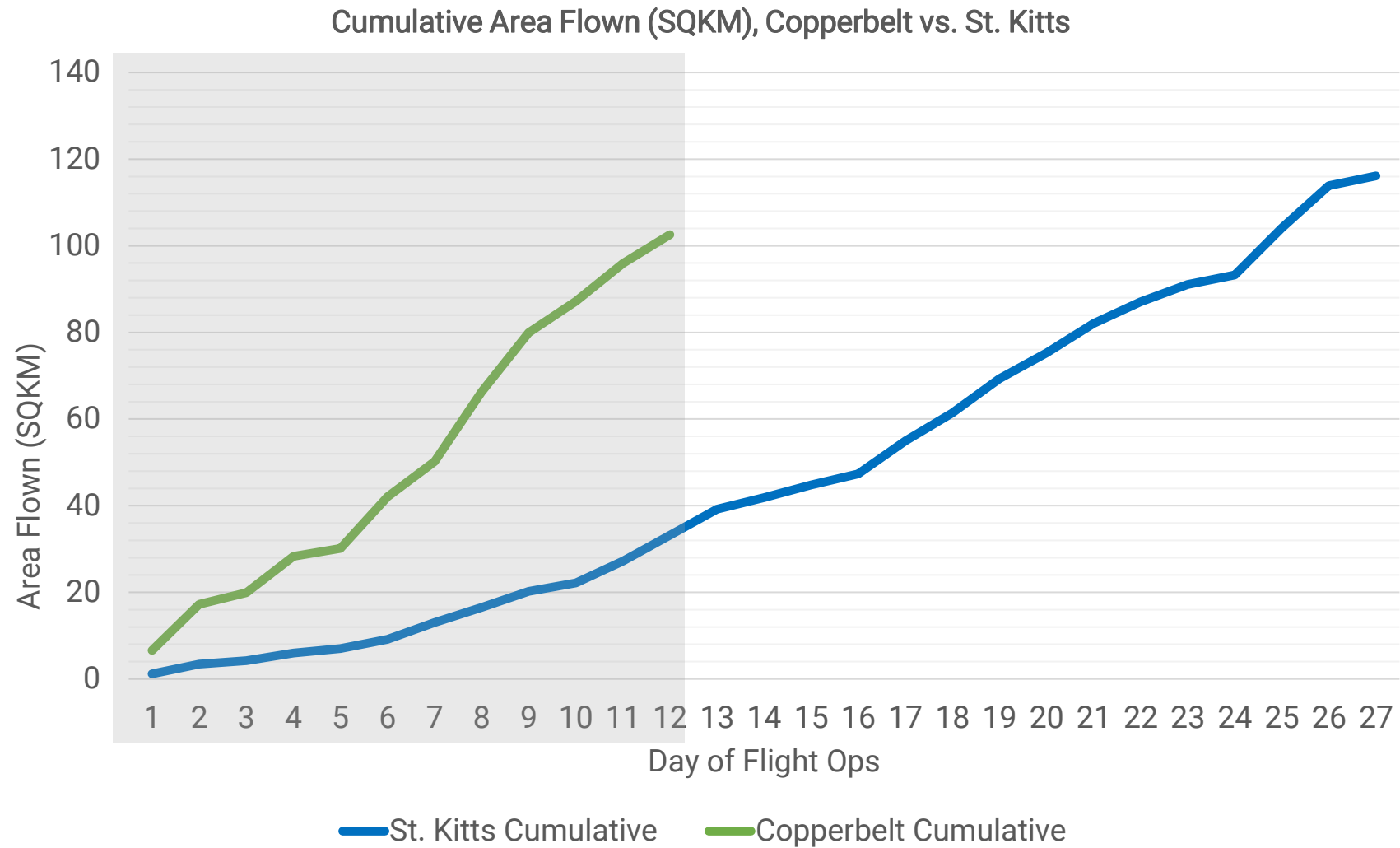
* Total sqkm flown (102.6) differs from AOI sqkm flown (78.9) due to buffer amount, bounding box of flight paths being larger than actual AOI

Area Flown (SQKM) by Date, Copperbelt Nov. 2020



Total Flight Days	12
Min Daily	1.9 km ²
Median Daily	8.3 km ²
Mean Daily	8.5 km ²
Max Daily	16.0 km ²

Cumulative Area Flown by Flight Ops Day: St.Kitts* vs. Copperbelt



*Excludes contractor ATI flights

Comparing First 12 Flight Ops Days: St.Kitts* vs. Copperbelt

	First 12 Days in St. Kitts	12 Days in the Copperbelt
SQKM Mapped, end of Flight Day 12	33.2 km ²	102.6 km ² ← 3.1x more!
Frontlap/Sidelap flight parameters	80/80	75/65
1 km ² mission grid, estimated flight time (hh:mm:ss)	00:48:02	00:35:10
Linear km flown	1,230.1	1,862.6
% of flight days with Wingtra	50%	100%
Drone flight above ground level	700ft	700ft
% SQKM Mapped with Wingtra	72.3%	100%
# flight days with two drones flying	0	8
# tech-down no-fly days	0	4
# weather-down no-fly days	2.5	1
AOI Mean Sea Level Elevation (AMSL)	100ft	4,145 ft.
Average surface daily windspeed (mph) ⁺ , noon-6pm	10.6	3
Average surface temp (°F) ⁺ , noon-6pm	83.6	96

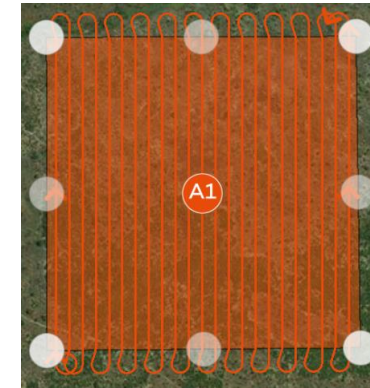
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*Excludes contractor ATI flights

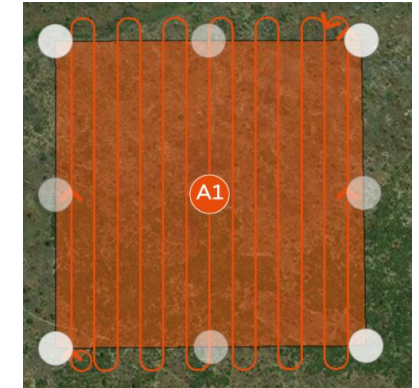
+ source: www.timeanddate.com

First 12 Days of Flight Ops : St.Kitts* vs. Copperbelt

- We completed in **12 flight days** in the Copperbelt what took **24 flight days** in St. Kitts; much due to reduced overlap constraints
- Given the reduced frontlap/sidelap requirements, we expected a **75% increase** in efficiency alone
- In reality, we observed a **104% increase** in efficiency
- That's an additional **29% increase in efficiency** not accounted for based on flight parameters



80% frontlap/80% sidelap



75% frontlap/65% sidelap

$$\text{Efficiency} = \frac{\text{Area flown (SQKM)}}{\text{Linear dist. Flown (km)}}$$

Campaign/Drone Comparisons

After controlling for differences in overlaps:

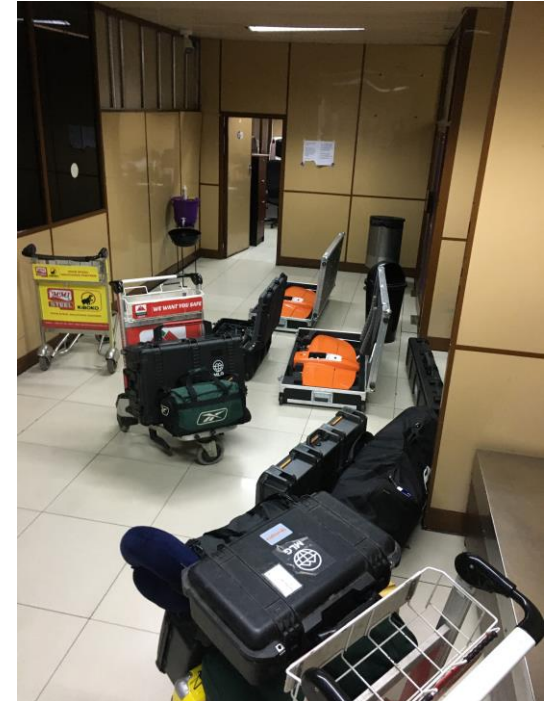
- We were **17% more efficient** using Wingtra in St. Kitts vs. eBeeX in St. Kitts
- We were **10% more efficient** using Wingtra in the Copperbelt vs. St. Kitts
- Relative to using 2 Wingtras in St. Kitts:
 - We were **13% more efficient** using 1 Wingtra in the Copperbelt
 - We were **9% more efficient** using 2 Wingtras in the Copperbelt
 - We were only **1% less efficient** using 1 Wingtra in St. Kitts



We need to work on logistics, hardware problems!

Persistent Challenges: St. Kitts and Copperbelt

- **Advanced planning:** Both campaigns developed very quickly. Ideally, these missions would be known and planned for 3+ months out for logistics and government approval reasons
- **Customs:** Importation of drones into foreign countries takes hours after already long travel. Bureaucratic slow-downs, mistrust over equipment.
- **Telemetry/Hardware:** Connections between drone and RC: Related to unregulated radio frequencies interfering with the drone frequency? Exploring this.
- **Bio breaks:** 11hr days in the field with no place to use the restroom.
- **Risks:** Flying over people, streets is not what the general international regulatory schema routinely permits for drones. What we do is unique!



After Action Reviews already conducted to identify issues and solutions (utilized & hypothetical)

Scenes from the Field – Base Camp



Scenes from the Field – Flight Ops



Scenes from the Field - Flight Ops



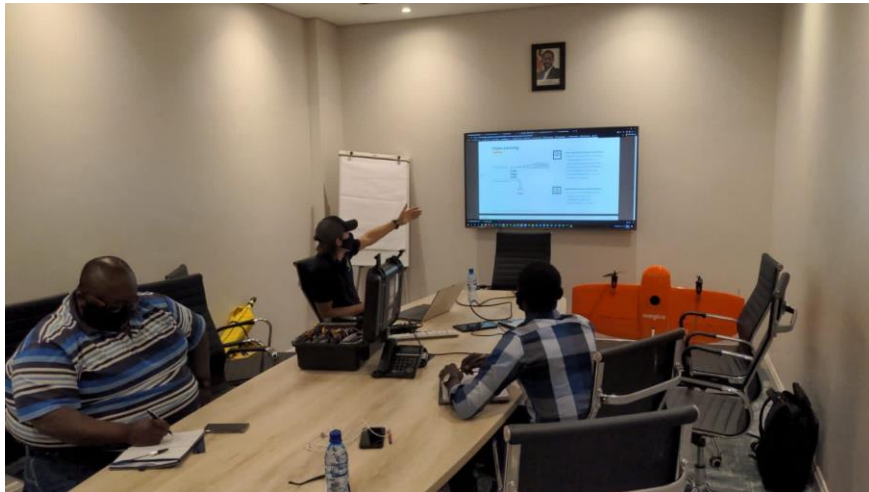
Scenes from the Field - Monumenting



Scenes from the Field - Surveying



Scenes from the Field - Training



Scenes from the Field – Sensitizing



Scenes from the Field – Sensitizing



Scenes from the Field – Grabbing Grub



Scenes from the Field – Raw Imagery



Scenes from the Field – Raw Imagery



Popular Music Among the Crew



Ben White

PLAYLIST

Zambian Jams Fall 2020

128257487 • 8 likes • 67 songs, 4 hr 38 min

Search in playlist

#	TITLE	ALBUM	DATE ADDED		
1	 Season Yanga Yo Maps, Bobby East	Season Yanga	Nov 5, 2020	♥	3:54
2	 Nimayewa Daev Zambia, T-sean	Never Been Easy	Nov 5, 2020	♥	4:33
3	 Waatagwan Oteya, Macky 2	Waatagwan	Nov 5, 2020	♥	3:37

<https://open.spotify.com/playlist/78NX52nDY7i7qb9FHpppR9>

An aerial photograph of a suburban neighborhood, showing a grid of streets and numerous houses with varying roof colors. The image is overlaid with a gradient that transitions from a bright green on the left to a deep blue on the right. The text 'QUESTIONS?' is centered in the upper half of the image.

QUESTIONS?