Search and Rescue with sUAS

Small Unmanned Arial Systems

Overview

- Limited Time – Hold questions until the end.
- sUAS use for SAR in SD Wing.
- Concept of Operations for Integrating sUAS into SAR (Search and Rescue)
- Limitations and Waivers
- Scenario for a Challenging Search

sUAS Operations in
the South Dakota Wing
of the

CIVIL AIR PATROL

CAP - Largest sUAS Operation in the US

We currently have over:

- 1,700 FAA registered airframes
- 1000 sUAS pilots

SD: DJI Mavic Enterprise 2

- 2 Airframes – Dual: W/ IR (Infrared) 160 x160 resolution.
- 2 Airframes – Zoom (4K)
- Locations – Subject to Change, but generally:
  - Rapid City, Custer, Miller, and Sioux Falls

DJI Mavic 2 Zoom

- 1 Airframe - New replacement for lost Mavic Enterprise.
- No Strobe, Spotlight, or Speaker
- Uses the “DJI Go” app instead of the “DJI Pilot” app.
- Greater flexibility with 3rd party apps.
- Currently does not have a Crystal Sky monitor with it. (Personal smartphone or tablet is needed.)

SD: Parrot

- 1 Airframe (Dual)
  - W/ IR (Lepton) 160 x160 resolution.
  - 4K Cameral with 4x digital zoom.
- Location: TBD
  - Training materials and standards will be developed in the Black Hills.
- Our Parrot kit contains a Mini-iPad.

SD Wing Qualified Individuals

- 8 sUAS Mission Pilots
  - (Part 107 Pilots)
- 2 sUAS Technicians
  - (Visual Observers, also in training for MP)
- 9 more in training status

On-going Operational Test and Development

- How do we use low-res IR for SAR?
  - What Settings to Use?
- How do we use 4K res for SAR?
- Scanner Skills for Viewing Video Feed
- Uploading Videos & Photos to Servers for Crowd Sourcing and Immediate availability to search assets
- Ground Team / Mission Base Coordination
- New sUAS: Parrot

Search and Rescue

SUAS CONCEPT OF OPERATIONS

sUAS Missions are Corporate Only

- The USAF has not yet approved sUAS for search and rescue missions by CAP.
- The USAF WILL NOT approve any sUAS missions with DJI products.
- CAP can not spend any military dollars on Chinese manufactured drones.

Nuances

- A USAF/AFRCC mission that uses aircraft and ground teams for search and rescue can work in conjunction with a sUAS mission.
- Approved Examples:
  - A sUAS is transported by a ground team for a search mission.
  - A sUAS is transported by an aircrew for a search mission.

Corporate vs AFAM

- There must be a Corporate Mission if sUAS are used.
- There must be an AFAM if the USAF will pay for anything.
- You use the AFAM to arrive to the mission base or staging area.
- You use the Corporate Mission to fly the sUAS.

Integration into ICS

- Pre-planned Standard Operating Procedures – Needs development
- Air Operations Branch or Ground Branch?
- Communication and Internet
- Hobbyist Joe Drone Pilot
  - Chain of Command
  - Safety
  - Public Affairs
  - Legal Considerations

Lesson #1 - Use the sUAS Early

- Establish a Baseline before all the foot tracks in the snow, grass, mud, etc.
- Get a lay of the land to maximize effectiveness of resources
- Use Thermal Imagery when the target is warm.

Determine:
Programed or Manual Flight Path?

- Environment
  - Night
  - BLOS
  - Terrain
- Time
  - Hasty Search
  - Grid Search
  - Detailed Search

Determine: Video or Photos?

Real Time Video

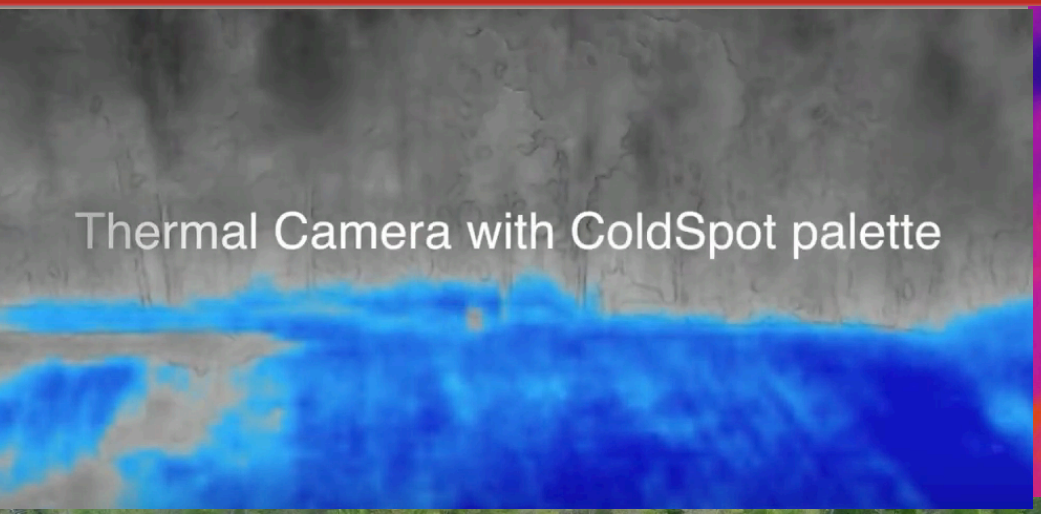
- Multiple Screens?
- Trained Scanners?
- Time since last contact?
- Cooperative Target?
- Environment?
- What is the target?

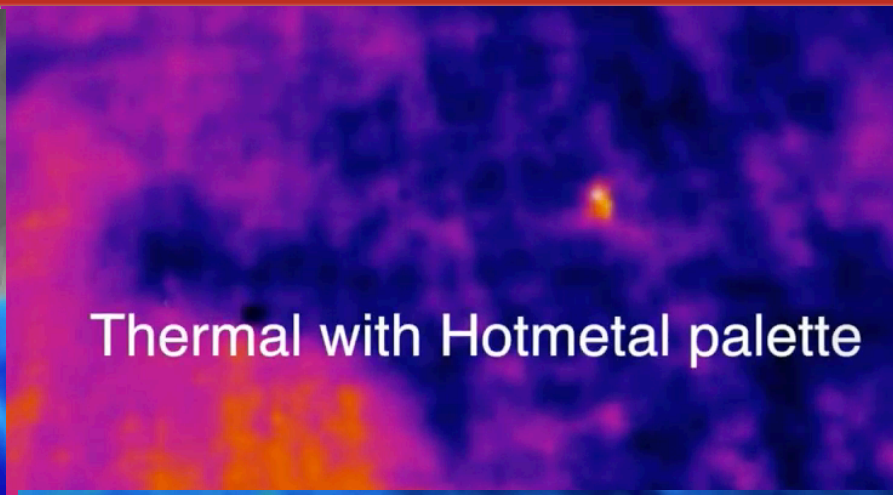
High Res Photos

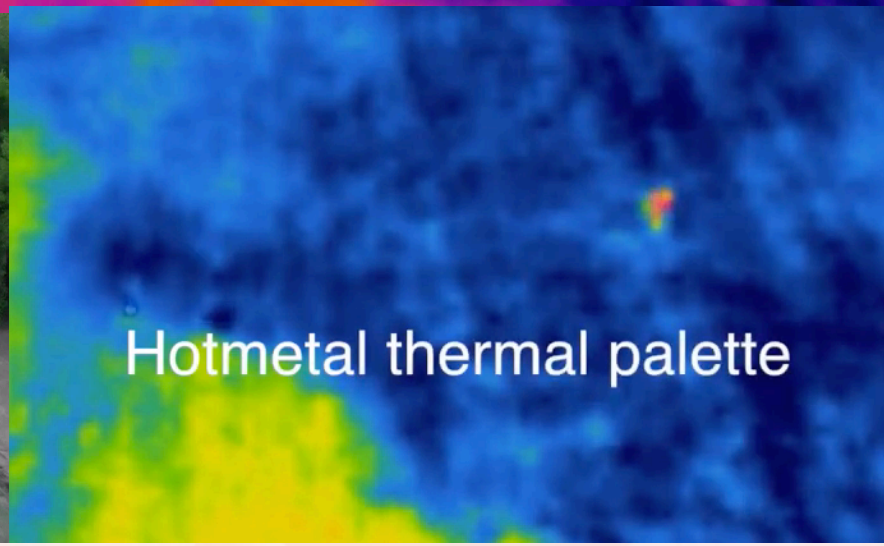
sUAS Team: Real time scanners or SD Card Transport?

- Standards for Operations
- Resources
  - Scanners – Trained and Proficient
  - Equipment Available
- Location

What is the “Right” Technology?







High Resolution Thermal

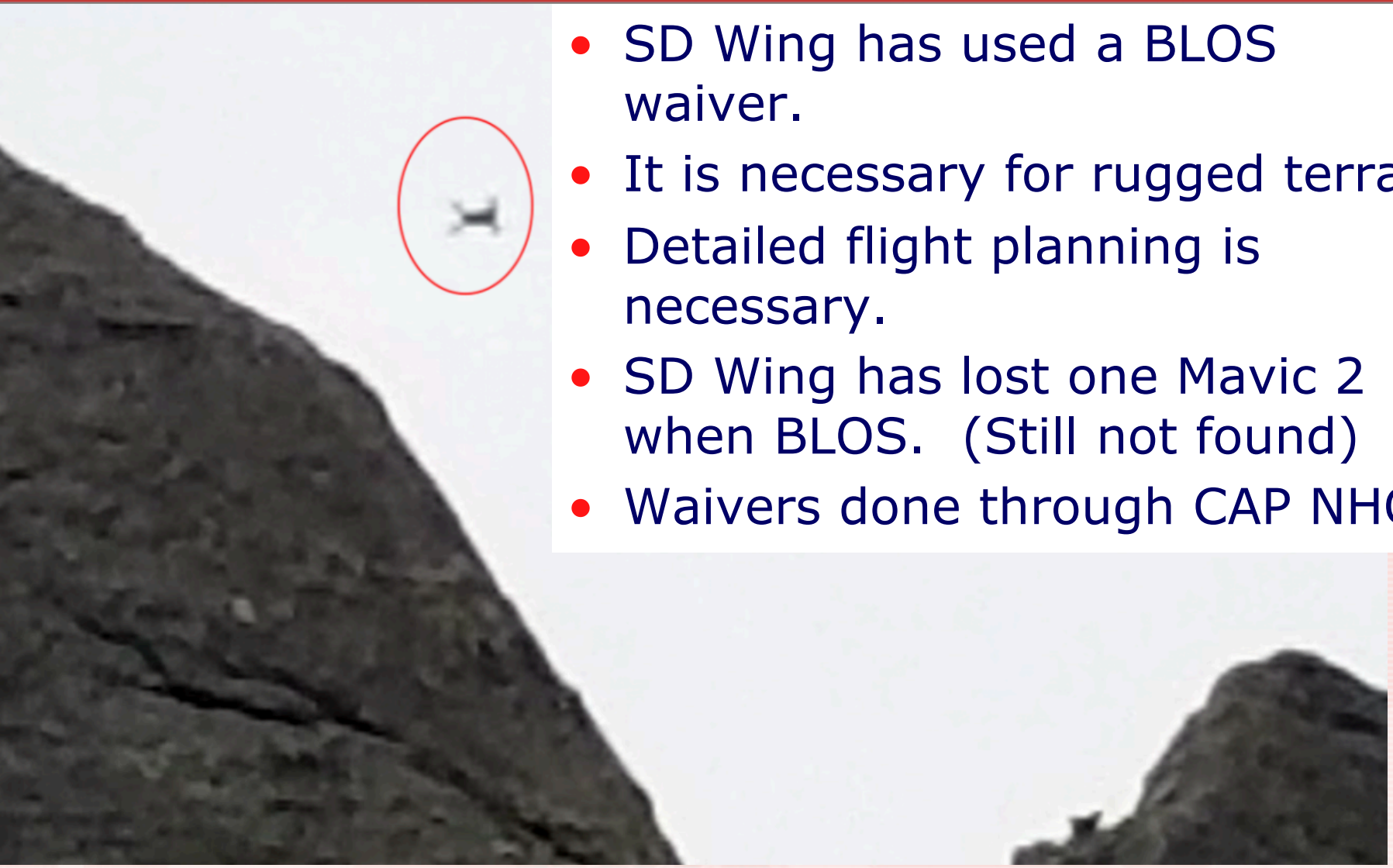
Night, BLOS, Flight Over People, Airspace

LIMITATIONS AND WAIVERS

Night

- FAA Waiver is Required
- CAP National HQ works directly with the FAA for waivers.
- The FAA Waiver requires specific stipulations such as being able to track the sUAS electronically, and have a anti-collision strobe plus position lights.
  - (This negates the ability to use the search light on the Mavic 2 Enterprise.)

BLOS – Beyond Line of Sight



- SD Wing has used a BLOS waiver.
- It is necessary for rugged terrain.
- Detailed flight planning is necessary.
- SD Wing has lost one Mavic 2 when BLOS. (Still not found)
- Waivers done through CAP NHQ.

Flight over Personnel

- Search Teams are NOT considered by the FAA to be part of the UAS operation.
- Therefore, the UAS may not be flown over searchers without an FAA waiver.

National Airspace System (NAS): Temporary Flight Restrictions (TFR)

- A TFR is a regulatory action that temporarily restricts certain aircraft from operating within a defined area in order to protect persons or property in the air or on the ground.
- DJI automatically prevents flight within a TFR. However…
  - If there's no internet, the controller doesn't know there is a TFR.
  - If internet is available, there is a process to bypass the automatic grounding.

TFR's for SAR

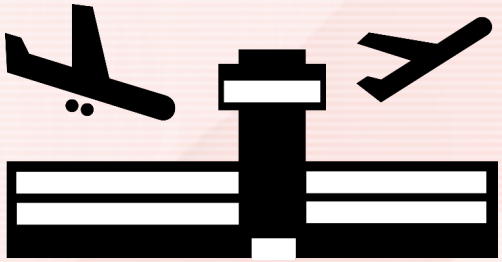
- The CAP will normally issue a TFR for SAR operations for both sUAS areas, and Search Areas with high numbers of search airplanes and helicopters.
- The local CAP Incident Commander is normally the authority for TFR's. However, if the local SAR has their own AOBD, the AOBD may be the authority.
- The AOBD might not be a CAP member.

LAANC: FAA's Low Altitude Authorization and Notification Capability system.

- Under the small UAS rule, pilots planning to fly in controlled airspace must receive an airspace authorization from the FAA.
- Pilots can receive near real-time airspace authorizations via LAANC.

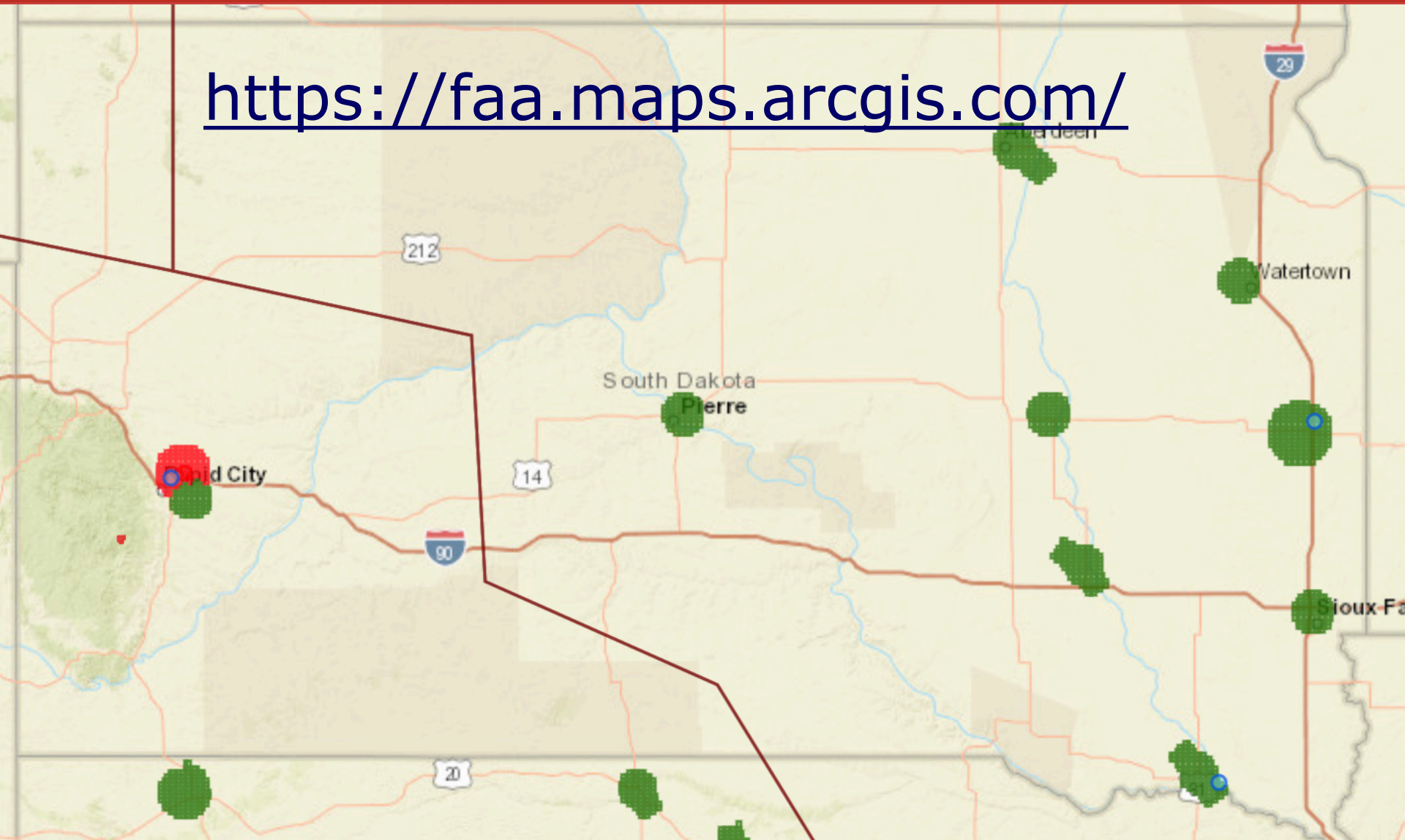
Airspace Authorization Changes

- It enables drone pilots access to controlled airspace near airports through near real-time processing of airspace authorizations below approved altitudes in controlled airspace.



FAA : Airspace Authorization Changes

https://faa.maps.arcgis.com/



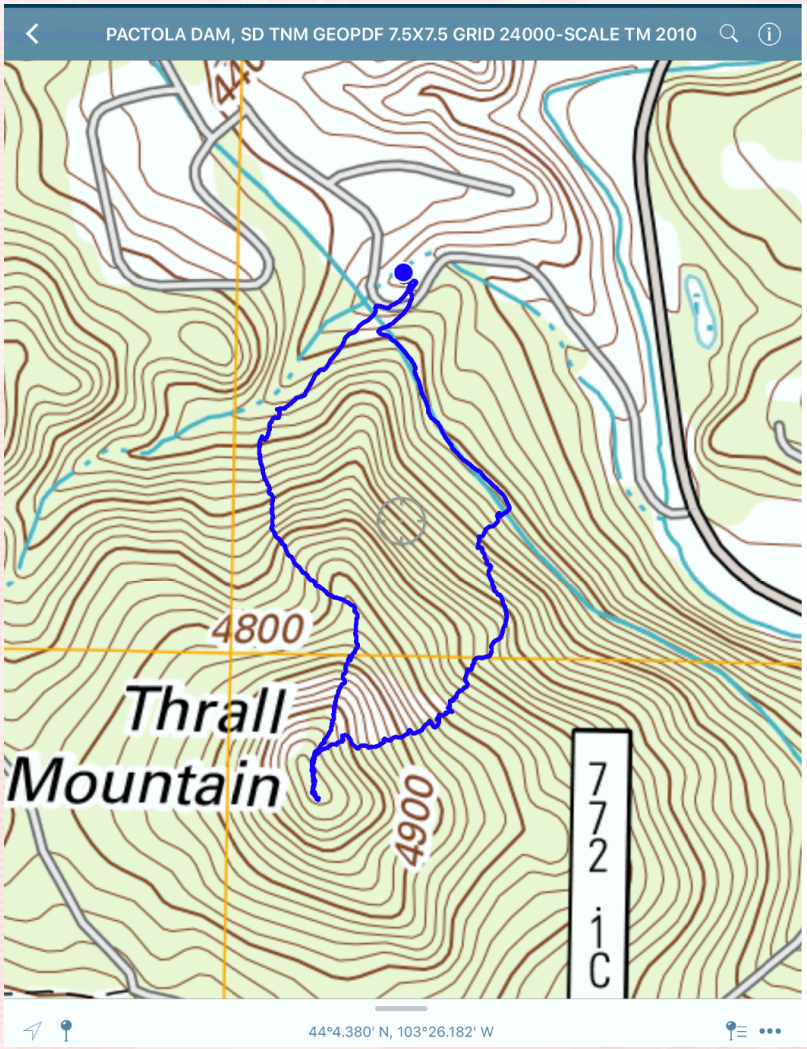
So now you know the concept of the operation. What about the details?

SCENARIO – PUTTING IT ALL TOGETHER

Scenario:

- Saturday morning, a solo hiker went hiking up his favorite mountain close to his home west of Rapid City
- At sunset, CAP gets a call from Pennington County SAR (PCSAR) that he's missing. They've been searching for him for three hours with no joy.

PCSAR supplied map.



- Change in elevation from bottom to top is 4340’ to 5080’ (740 feet total)
- Very steep incline over boulder fields, and tree covered hillsides

Immediate Actions

- Find qualified personnel
  - CAP IC/LO
  - sUAS MP
  - sUAS Tech
  - sUAS Scanner
- More sUAS teams
- Mission Staff
  - OSC, PSC, AOBD, GBD, PIO, MSO
- Ground Teams

Find and Evaluate the Staging Area

- Close to or with PCSAR?
- Internet?
- CAP Radio? Highbird Required?
- Bring our "Stuff"
  - Vehicles
  - Mobile Command Post
    - Trailer / Shelters / Generator
  - sUAS aircraft, Monitors, etc.

OK, We're on Scene. Now what?

- Check in with the IC
- Determine what waivers are needed and coordinate.
- Develop the search plan.

Search Plan Considerations

- Where do we operate from?
  - Top of the mountain – more likely that you can see the sUAS.
  - But can you effectively operate from there? Consider SD Card / Battery Swap plan. (Ground teams!)
- Night
- Terrain
- Equipment and personnel available

sUAS Hasty Search

- Hasty Search / sUAS Data Gathering
  - Might find the hiker
  - Day Photos – Possible foot tracks
  - Look for hazards, terrain elevations, how tall are the trees?
  - Safe T/O and landing areas?
  - Are thermal conditions compatible with use of IR?
  - Determine what IR settings are required based on current conditions.

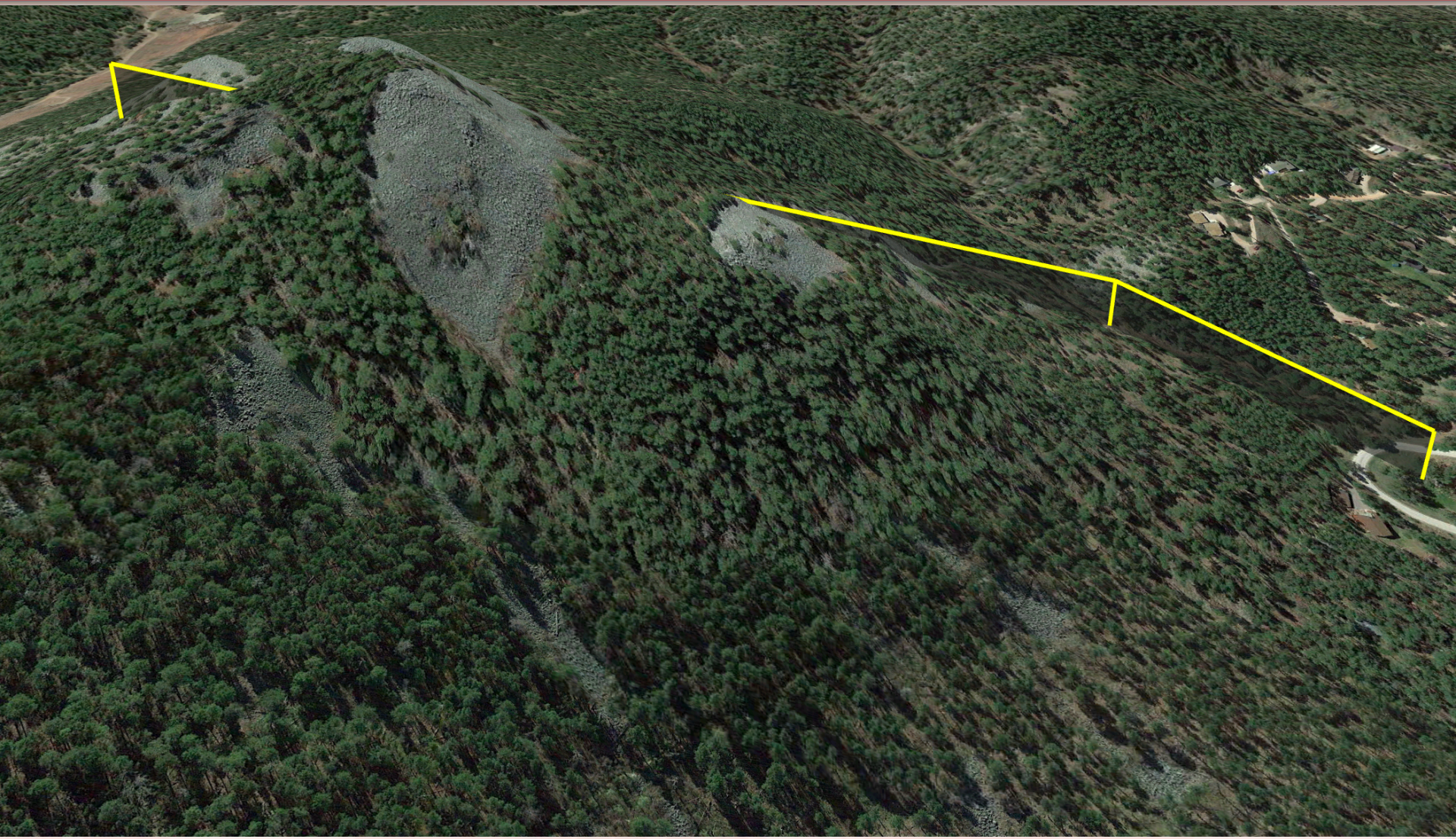
Night with Terrain

- Difficult but maybe the only solution we have right now:
  - Plan route on Google Earth with elevations
  - Import KLM file to DJI Pilot
  - Adjust all waypoints and flight plan settings on DJI Pilot
- Fly the route / Take video
- Download the video and/or relay the video to a large screen monitor.

Google Earth (GE)

- While MP is doing Hasty Search, someone else is planning.
- Terrain - Show Elevation Profile
- Create a folder
- Create a path.
  - Create enough points in the path to adjust for altitude and camera direction.
  - Look at the elevation of the terrain of each point on the path.

We don’t fly sUAS’s underground



XL File – Altitude Calculation

- Each point needs an Altitude above the elevation of the Take-off (Home) point, and add the clearance above the trees.
- This elevation needs to be converted from feet to meters.

Google Earth (GE)

- Adjust the altitude at each point.
- What altitude should we plan for?
  - How tall are the trees?
  - IR – 80’ AGL Maximum.
  - Photos –
    - 60% overlap with tracks.
    - Track Spacing

Math for Pros

$$\alpha = 2 \arctan \frac{d}{2f}$$

What is our photo coverage on the ground?

- Simple Math – Applies to Mavic
- Zoomed Out: (and M2e Dual)

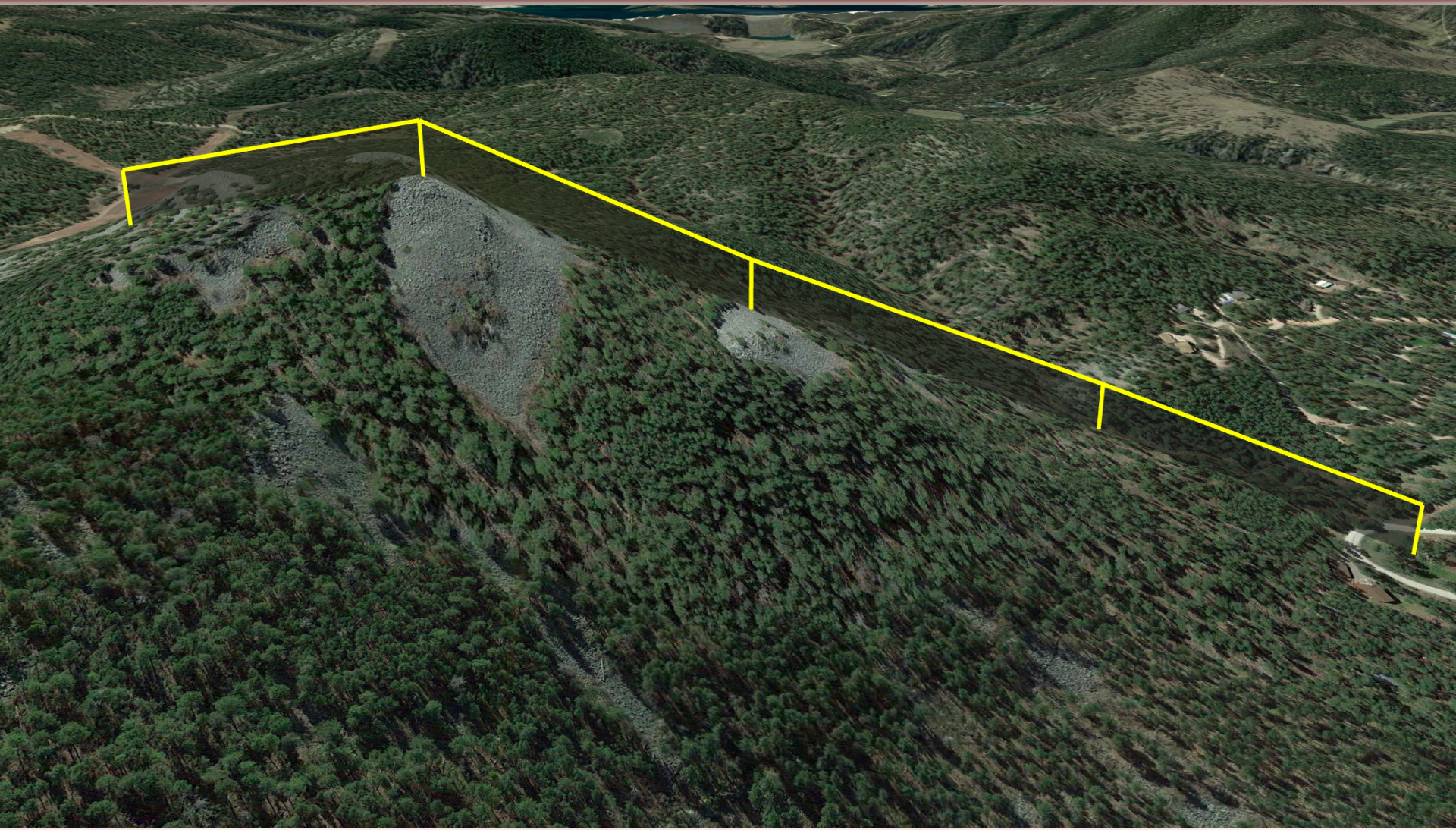
  Feet AGL x 4 = Photo width in feet on the ground.
- Zoomed In:

  Feet AGL = photo width in feet on the ground.

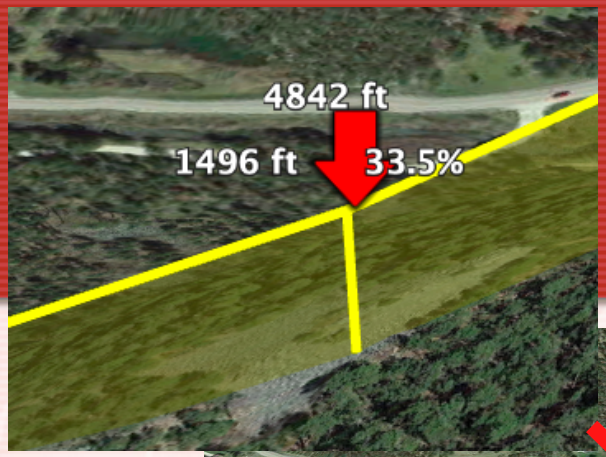
Altitude Considerations – Track Spacing

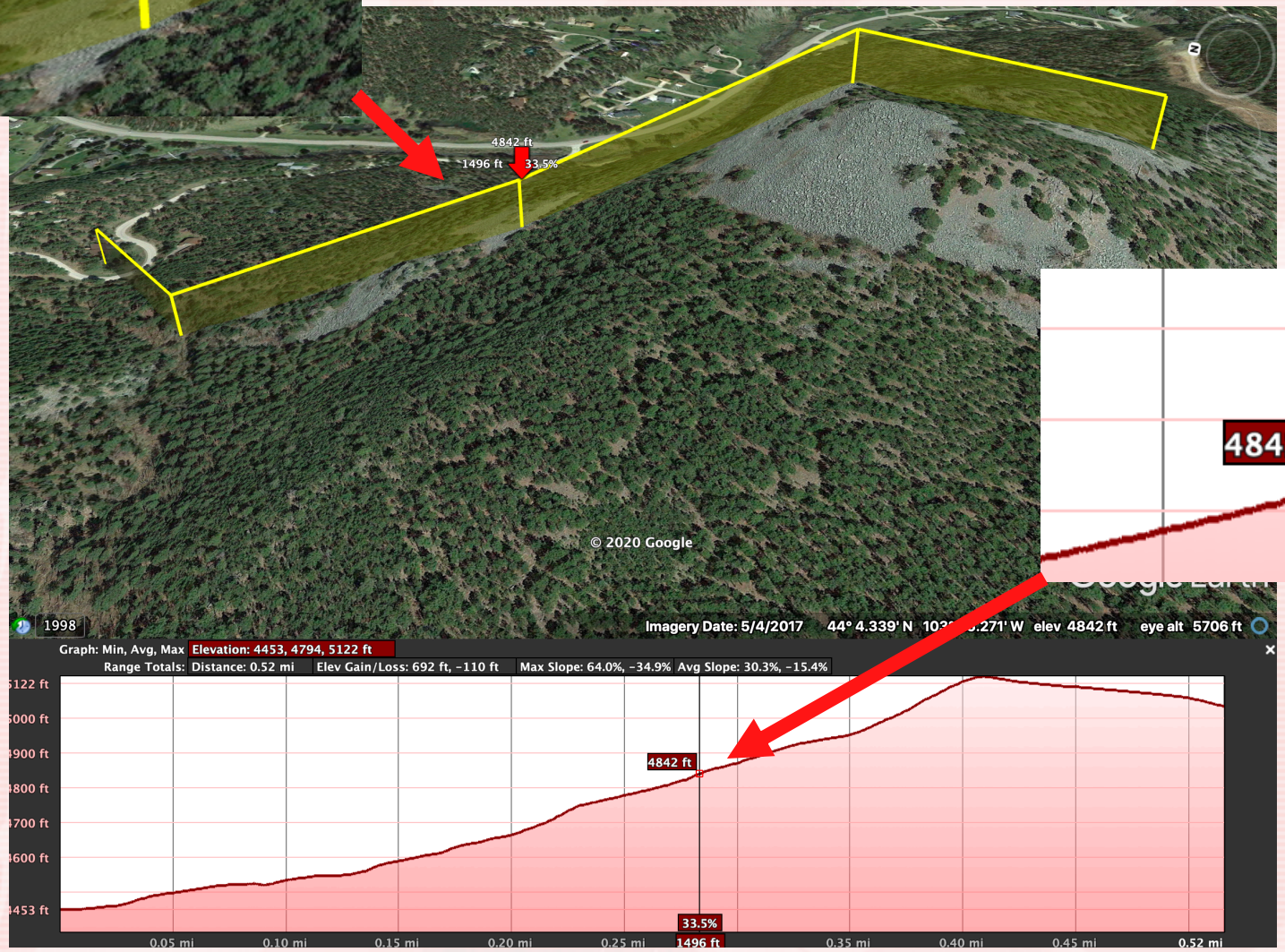
- So, if we shoot straight down from 80’ AGL, we get 80’ x 4= 320’ photo width.
- 320’ x 60% = 128’ track spacing for overlap.
- 128’ / 6076’= track spacing of .02 nm, or 48 tracks per 1 NM.
- If we shoot at an angle – we need to be lower to the ground to get the resolution required to detect the target with IR.
- We may be able to see the target with IR, thus be further away – but not “Detect” it.

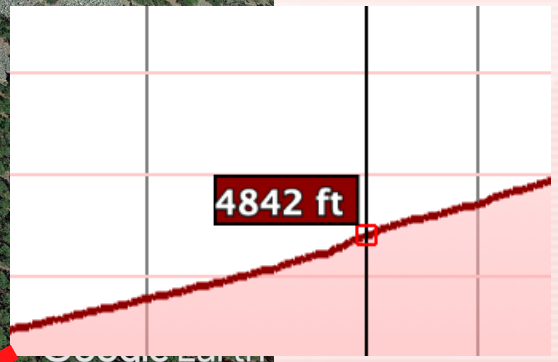
Looking West



Elevation of terrain (Not trees) (Looking East)







XL Spread Sheet

Enter terrain from Google Earth

Enter default route info

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	File Name:	Pl	Trigonometry.xlsx											
2	Route Defa	ts:	Meter conversion		High/Low Elev			Speed:	Height:	See note	Yaw:		Gimbal:	
3			3.2808		Locked cells			2	30	meters	Set Each WP		Set each WP	
4	Waypoints		Terrain Elev (ft)	Ht above T/O (ft)	Ht above T/O (m)	Set WP Ht (m)	Fly Ht (ft)	Leg Heading	Yaw	Rotation	Pitch	WP Actions			
5	Takeoff		3707											
6	WP 1		3710	3	0.9	30.9	101.4	360	0	Auto	-60	Video ON		
7	WP 2		3813	106	32.3	62.3	204.4	-120	0	Auto	-20			
8	WP 3		3813	106	32.3	71.0	232.9	-120	-120	Auto	-20			
9	WP 4		3865	158	48.2	78.2	256.4	-180	-120	Auto	-45			
10	WP 5		3865	158	48.2	78.2	256.4	-180	-180	Auto	-65			
11	WP 6		3801	94	28.7	58.7	192.4	85	-180	Auto	-30			
12	WP 7		3801	94	28.7	54.0	177.2	85	85	Auto	-65			
13	WP 8		3782	75	22.9	52.9	173.4	-10	85	Auto	-65			
14	WP 9		3782	75	22.9	52.9	173.4	-10	-10	Auto	0			
15	WP 10		3708	1	0.3	30.3	99.4	-10	-10	Auto	-75	Video OFF		
16	WP 11													
17	WP 12													
18	WP 13													

XL Spread Sheet

Enter values as appropriate

Rotation "Auto" recommended

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	File Name:	Photo Trigonometry.xlsx												
2	Route Defaults:		Meter conversion		High	Elev		Speed:	Height:	See note			Gimbal:	
3			3.2808		Locked cells			2	30	meters		Set Each WP	Set each WP	
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13	WP 8	3782	75	22.9	52.9	173.4	-10	85	Auto	-65				
14	WP 9	3782	75	22.9	52.9	173.4	-10	-10	Auto	0				
15	WP 10	3708	1	0.3	30.3	99.4	-10	-10	Auto	-75	Video OFF			
16	WP 11													
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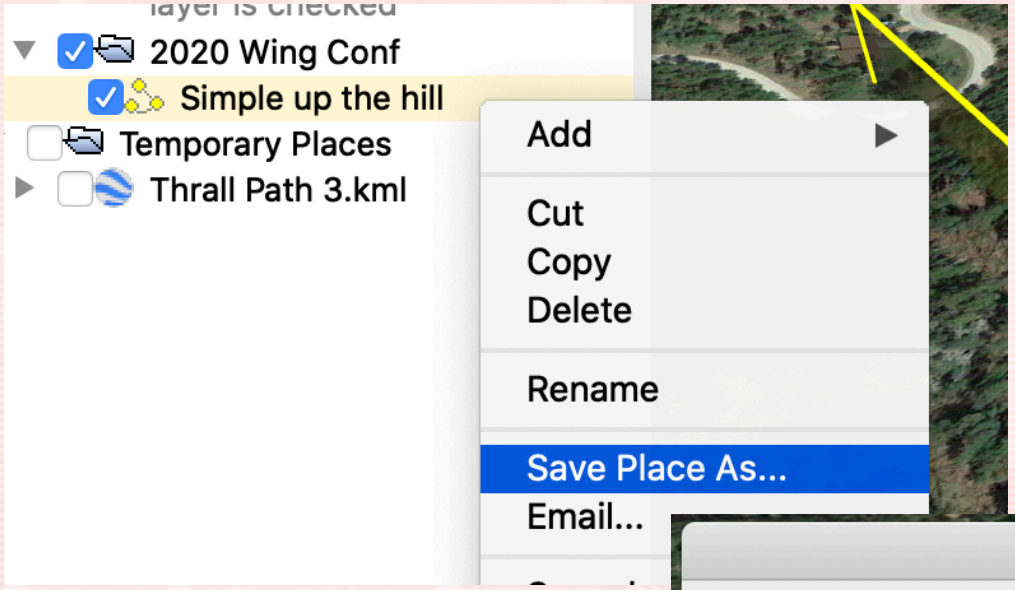
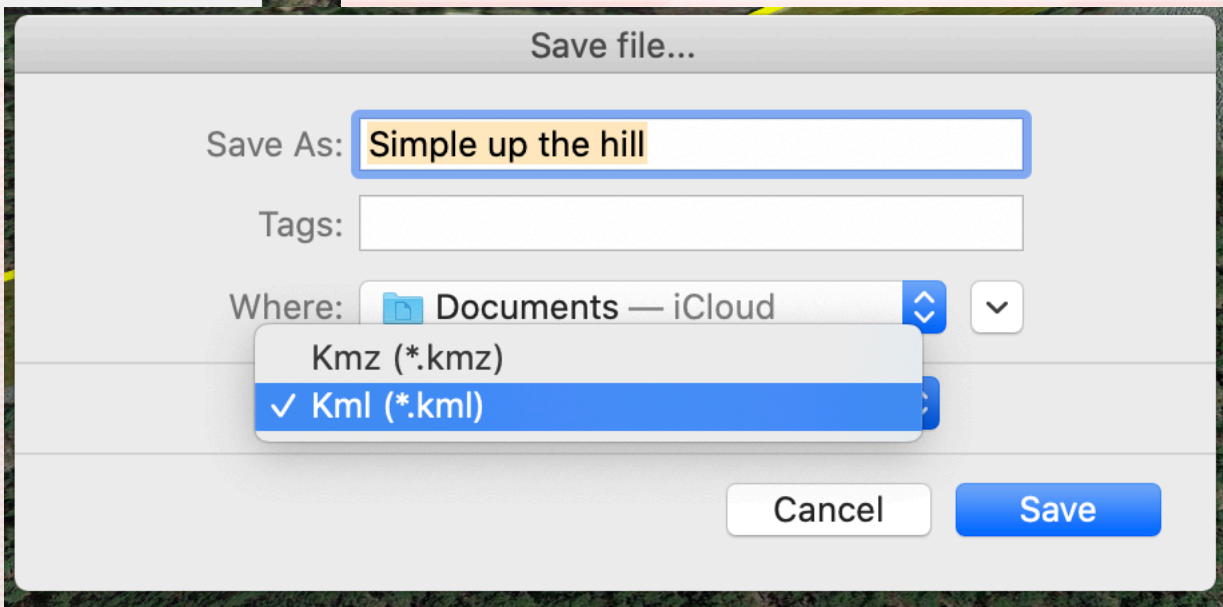
Export KML File

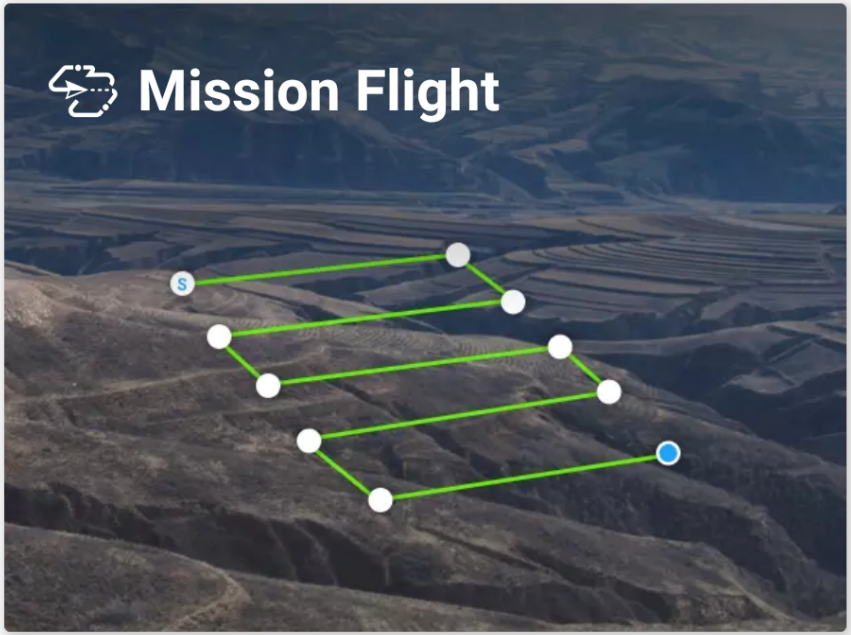




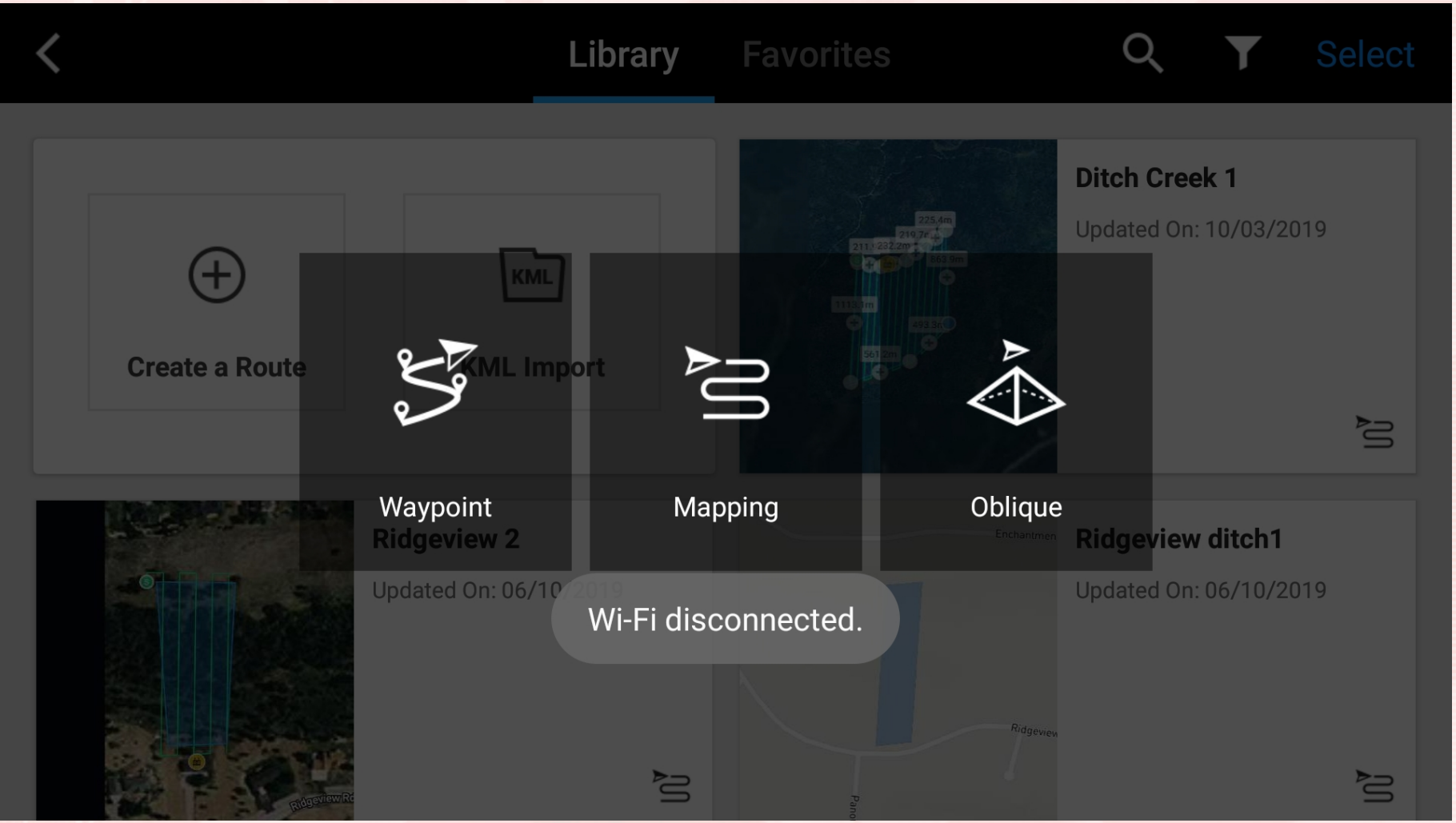
Import KLM File to DJI Crystal Sky Monitor/ DJI Go

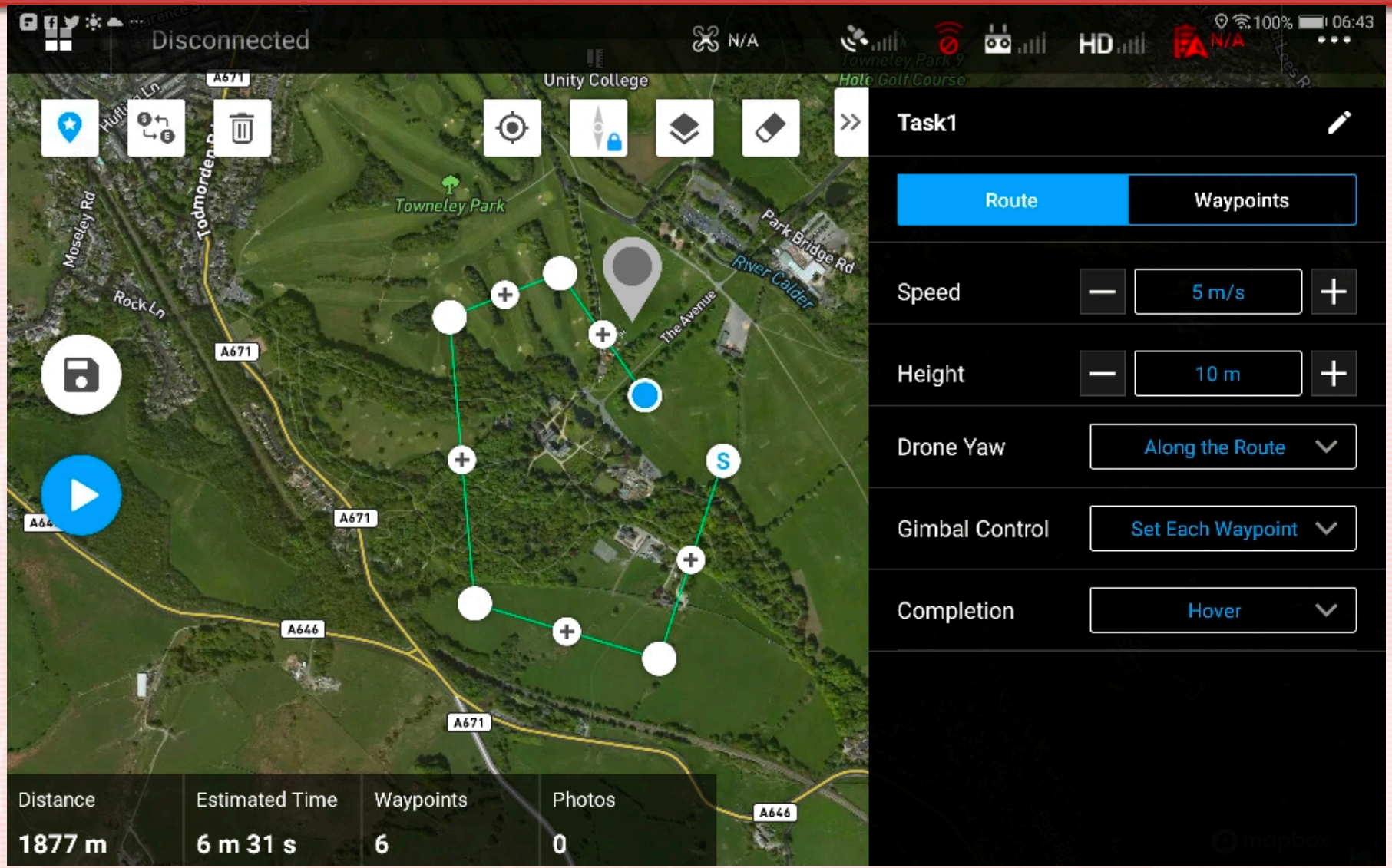
- Use a USB thumb drive or direct connection to laptop. Possibly drop box, or other file server too.
- Create a route by importing the KLM file.
- The KLM file will have NO elevation data in it.

PILOT



- Aircraft not connected.


Library
Favorites
Select
Create a Route
KML
KML Import
Waypoint
Mapping
Oblique
Ditch Creek 1
Updated On: 10/03/2019
Ridgeview 2
Updated On: 06/10/2019
Ridgeview ditch1
Updated On: 06/10/2019
Wi-Fi disconnected.


Disconnected
N/A
HD
100%
06:43
Unity College
Towneley Park
Moseley Rd
Todmorden Rd
Rock Ln
Park Bridge Rd
River Calder
The Avenue
A671
A646
Task1
Route
Waypoints
Speed
5 m/s
Height
10 m
Drone Yaw
Along the Route
Gimbal Control
Set Each Waypoint
Completion
Hover
Distance
1877 m
Estimated Time
6 m 31 s
Waypoints
6
Photos
0

XL Spread Sheet

Enter these values into DJI Pilot Flight Plan

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	File Name:	Photo Trigonometry.xlsx												
2	Route Defaults:		Meter conversion		High/Low Elev			Speed:	Height: See note		Yaw:		Gimbal:	
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15	WP 10	3708	1	0.3	30.3	99.4	-10	-10	Auto	-75	Video OFF			
16	WP 11													
17	WP 12													
18	WP 13													

Wrap Up

- We are a Professional Search and Rescue organization.
- We need experts that can use Google Earth, Excel, and the sUAS programs.
- We need more Techs, MPs, and MSA's.
- We need people that are available to respond immediately.
- Technology is CONSATANTLY changing.

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QUESTIONS?