Flight Planning Challenge

Spring Semester 2022

Contact: Tony.Grichnik@BlueRoofLabs.com

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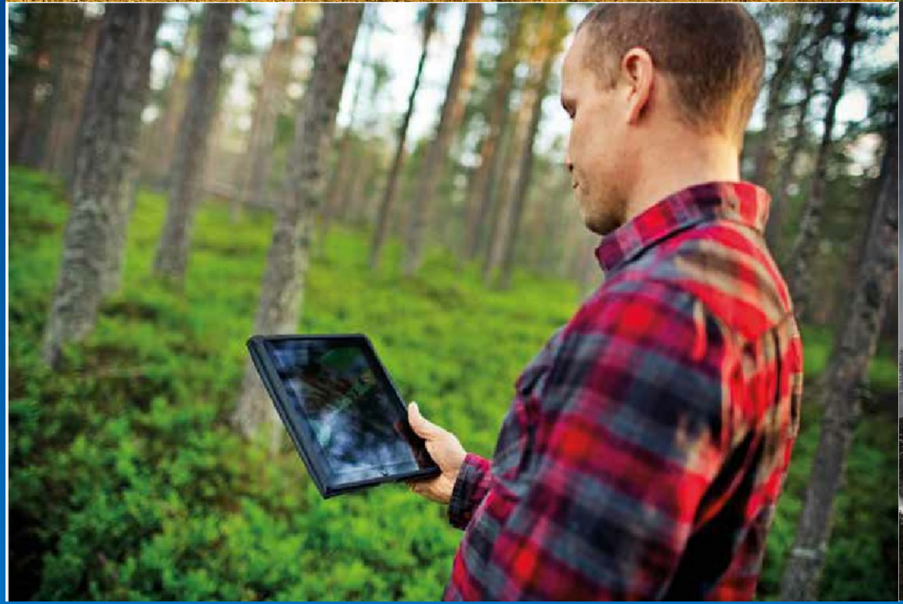

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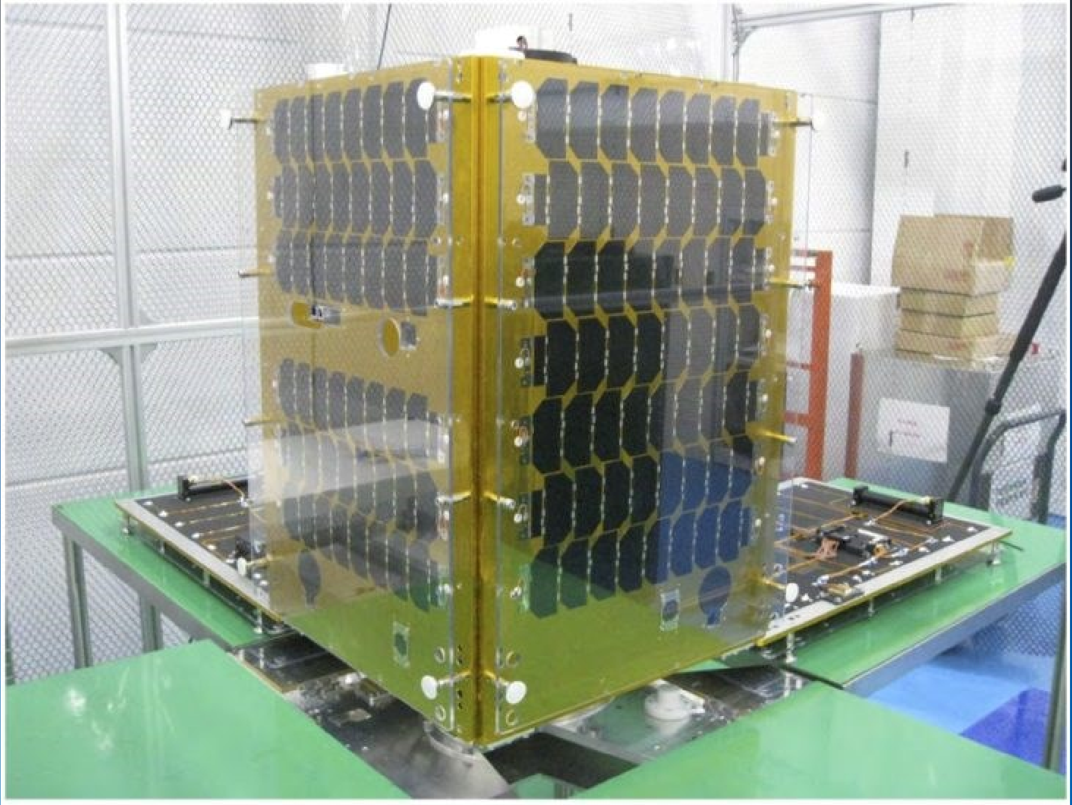
So, satellites?



Canon CE-1 "cubesat" for space photography via a website
Source: https://www.canonwatch.com/canons-satellite-ce-sat-1-is-in-orbit-building-a-high-resolution-earth-imaging-system-using-eos-5d-mark-iii/
See Also: https://www.diyphotography.net/canon-lets-you-shoot-photos-from-space-with-its-new-ce-sat-1-microsatellite-emulator/

- GREAT for large areas, but not great for higher resolution imaging of smaller areas
- Often not available on the desired schedule (e.g. users need the images when they NEED them, maybe not when the satellite is overhead)
- Retasking a satellite uses up precious on-board fuel, so they don't often change paths
- Can be a VERY expensive way to get an image (although it's getting cheaper over time)

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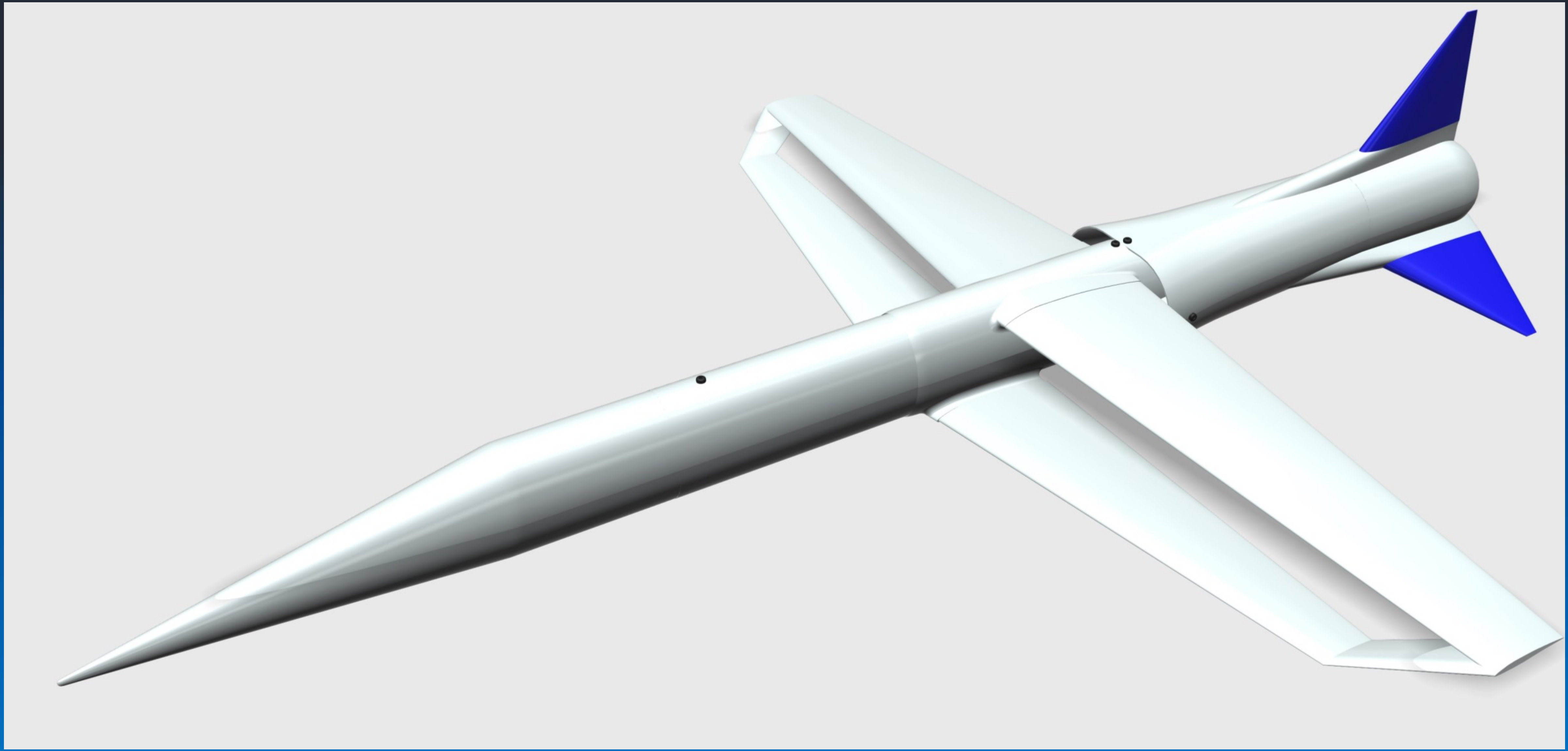
So, quadcopters?

- OK for short range cargo delivery and picture taking (e.g. everybody can!)
- While they are fast in short bursts, they are pretty slow vs. area covered when you include recharge or battery swap times
- Low battery conditions end ungracefully (read: it becomes an expensive rock)
- Loud, LOUD, ***<u>LOUD!!!</u>***

BRL Short-range EDF-powered quadcopter solution with 2 emergency blood delivery modules (2 x 500mL of blood delivered in sealed, temperature-controlled modules)



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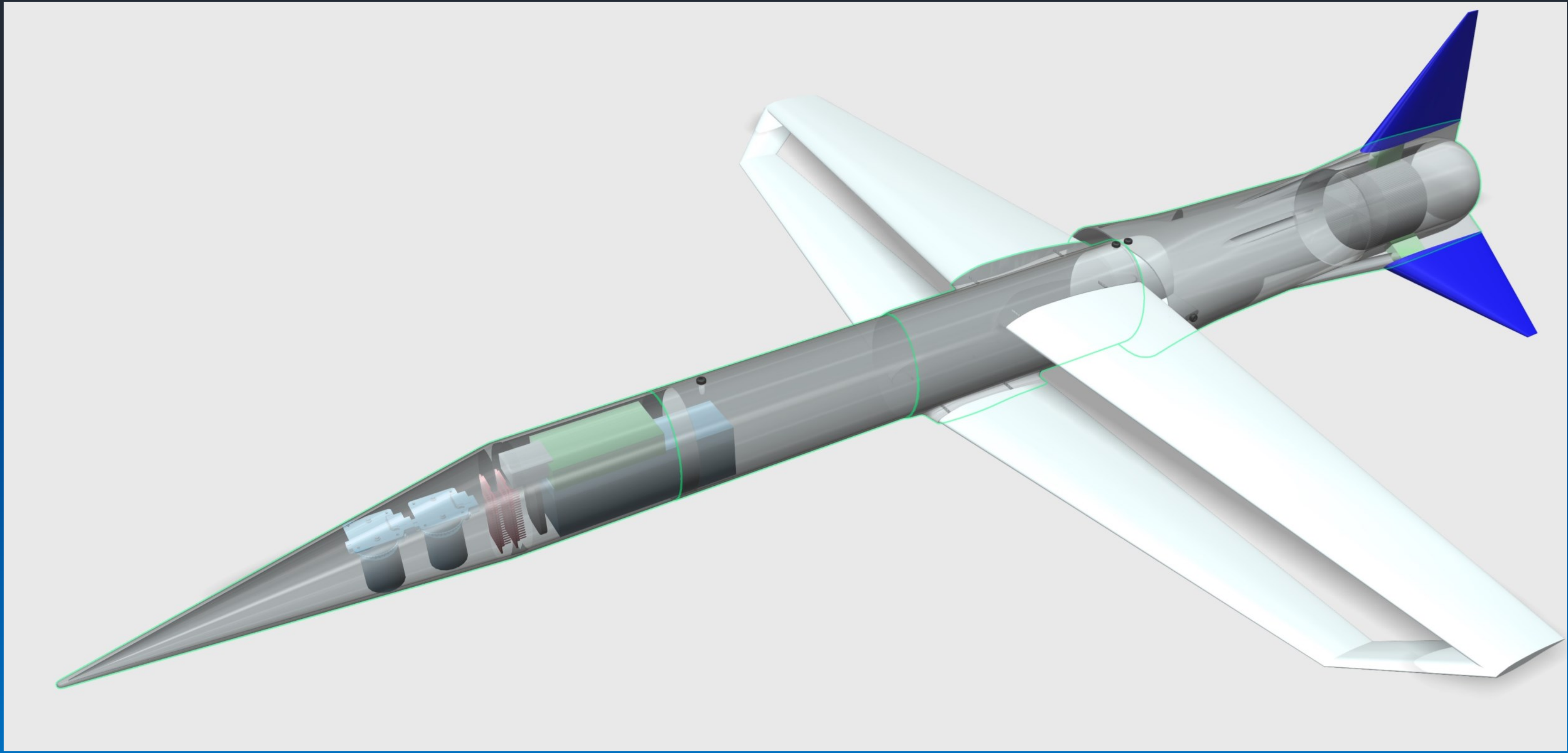

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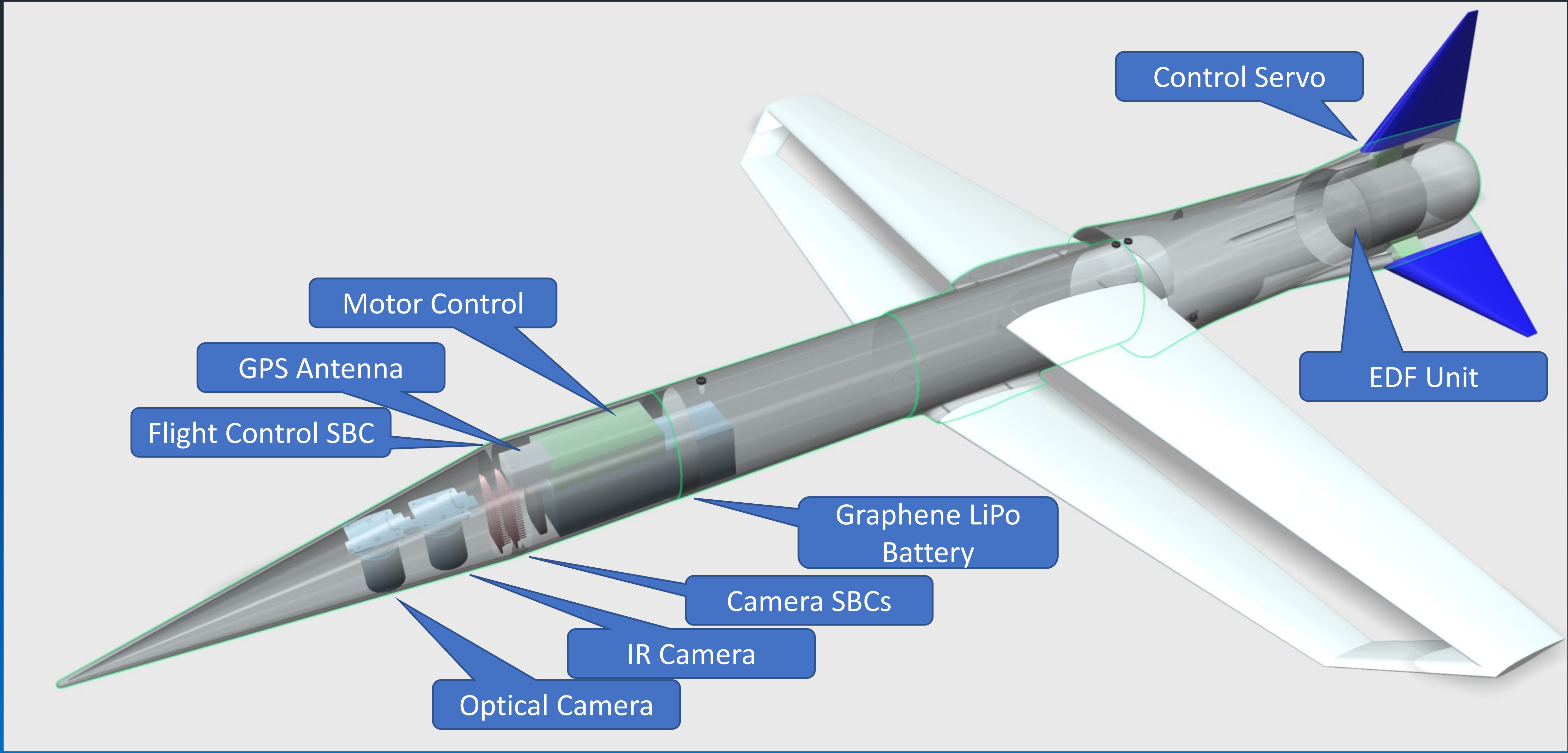

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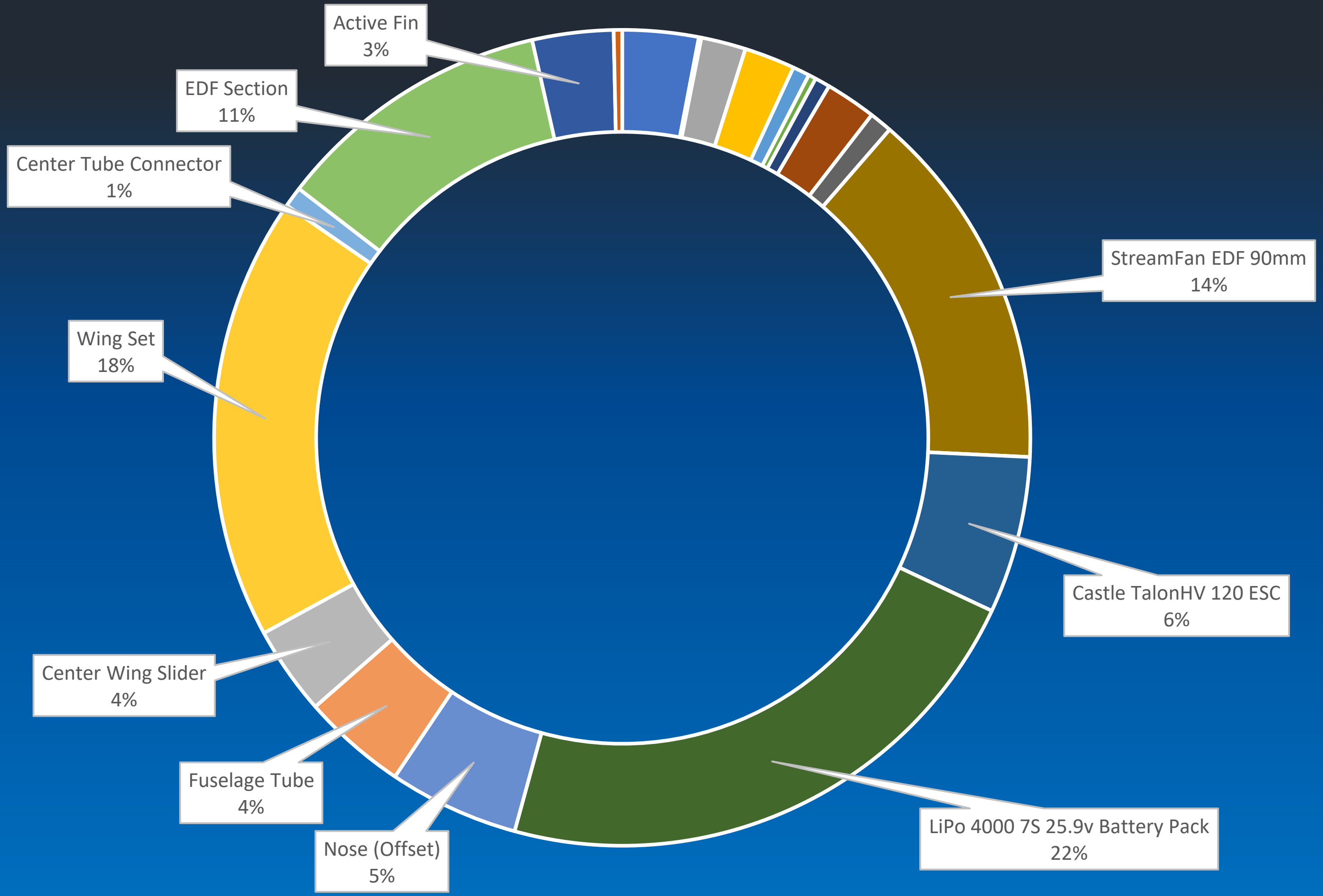
AG3-10 Weight Budget

2990g Total



43% Propulsion and Energy Storage
46% Structural Components
11% Controls and Sensor Package

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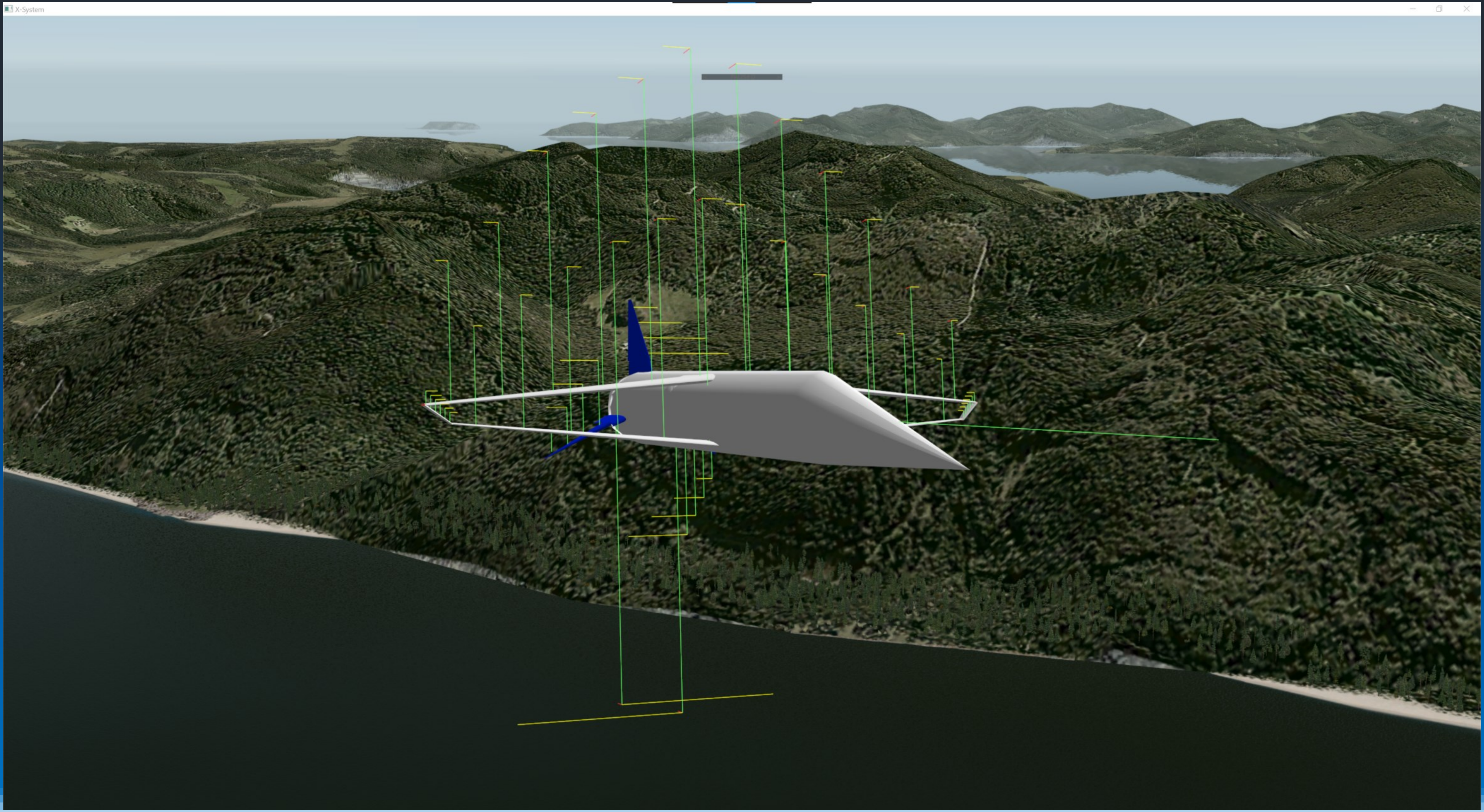

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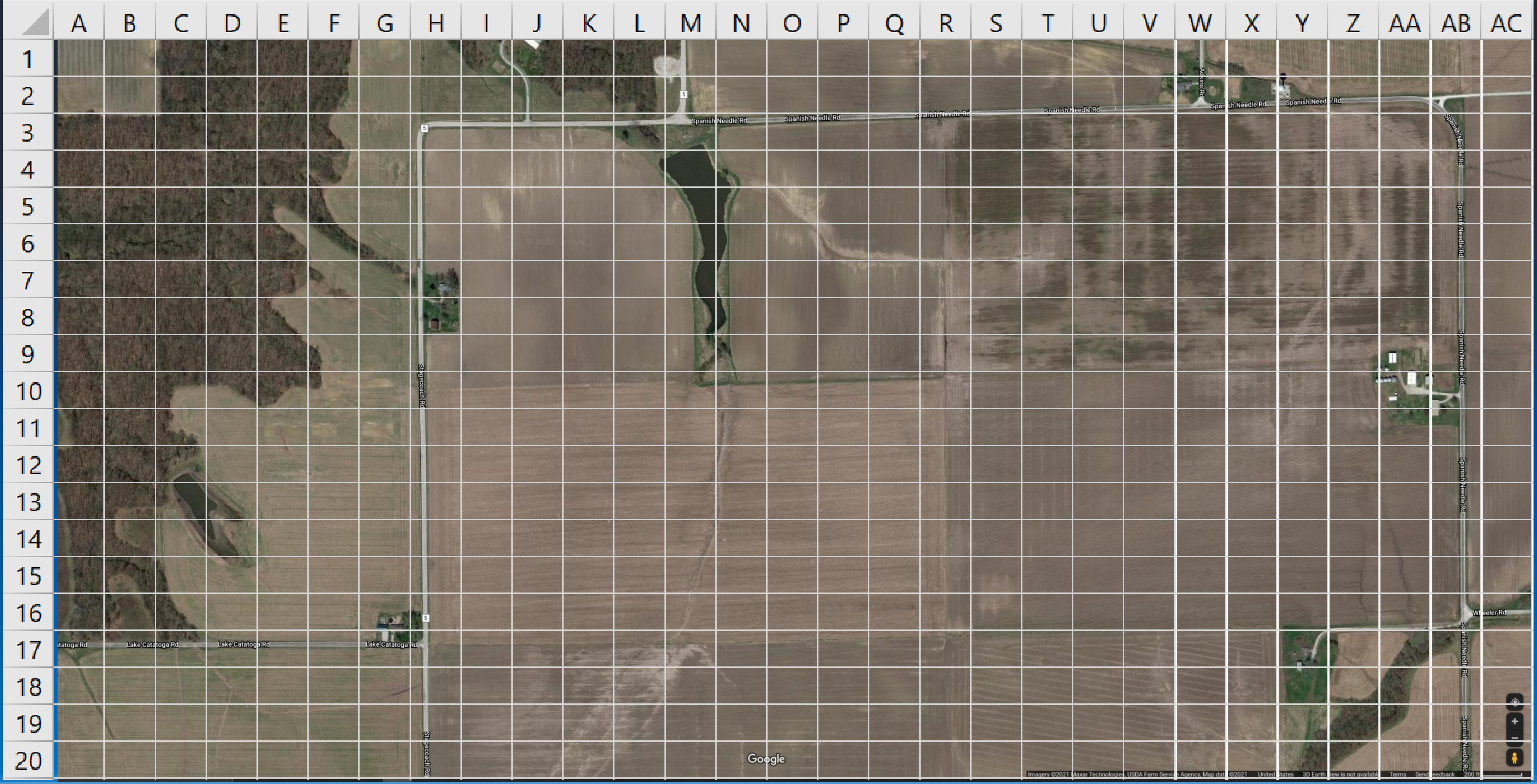
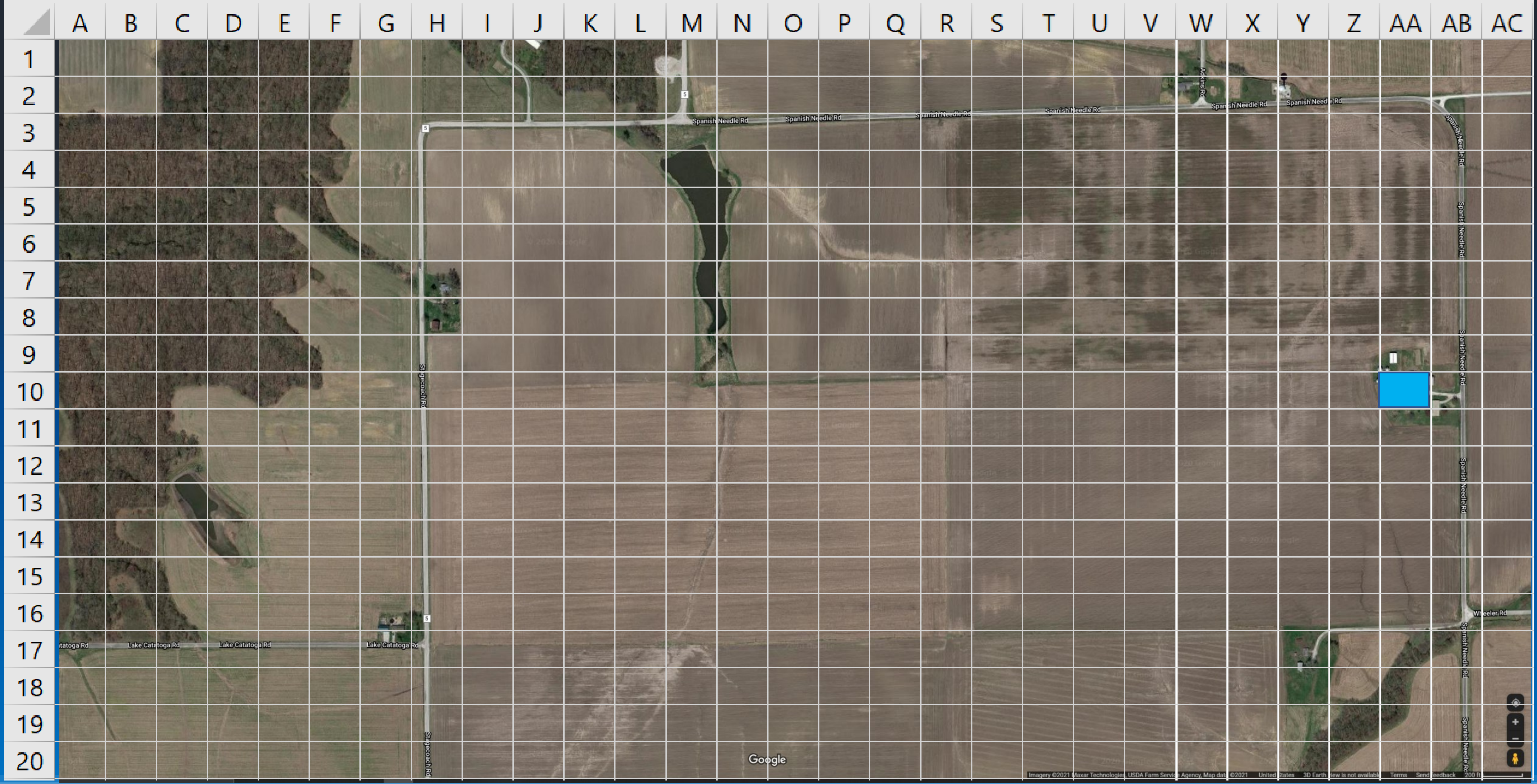

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA AB AC
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Spanish Needle Rd
Lake Catatoga Rd
Stagecoach Rd
Wheeler Rd
Google



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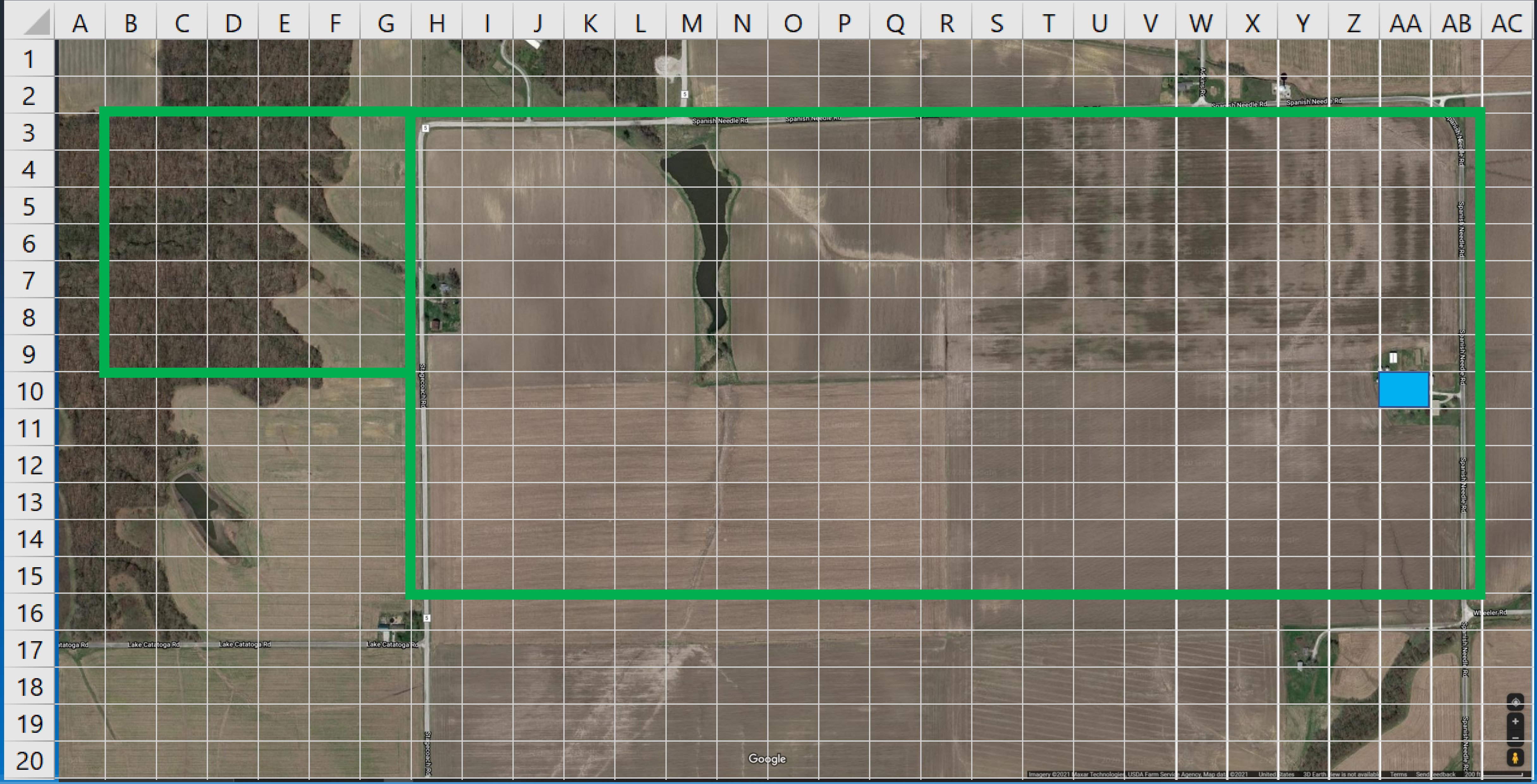

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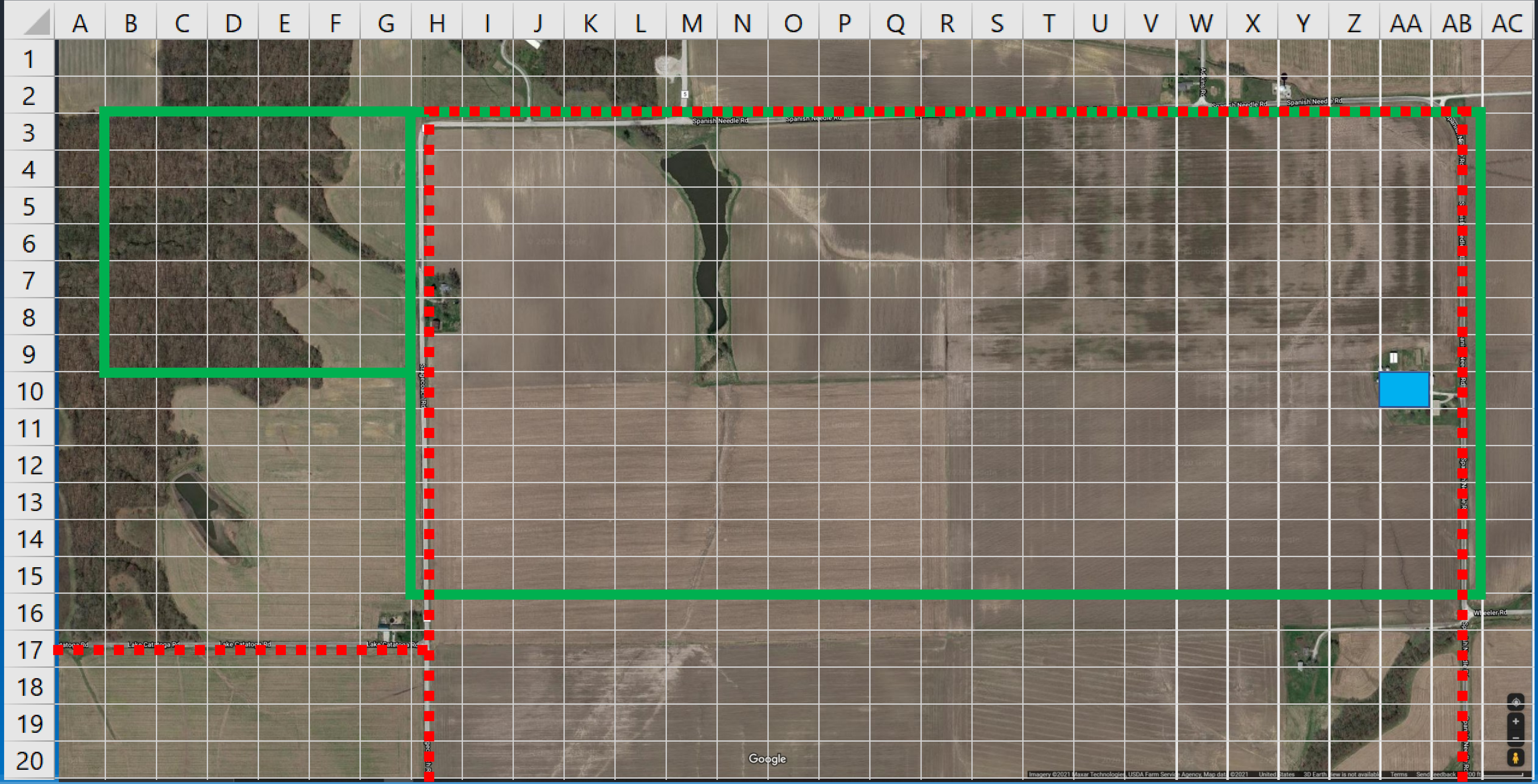

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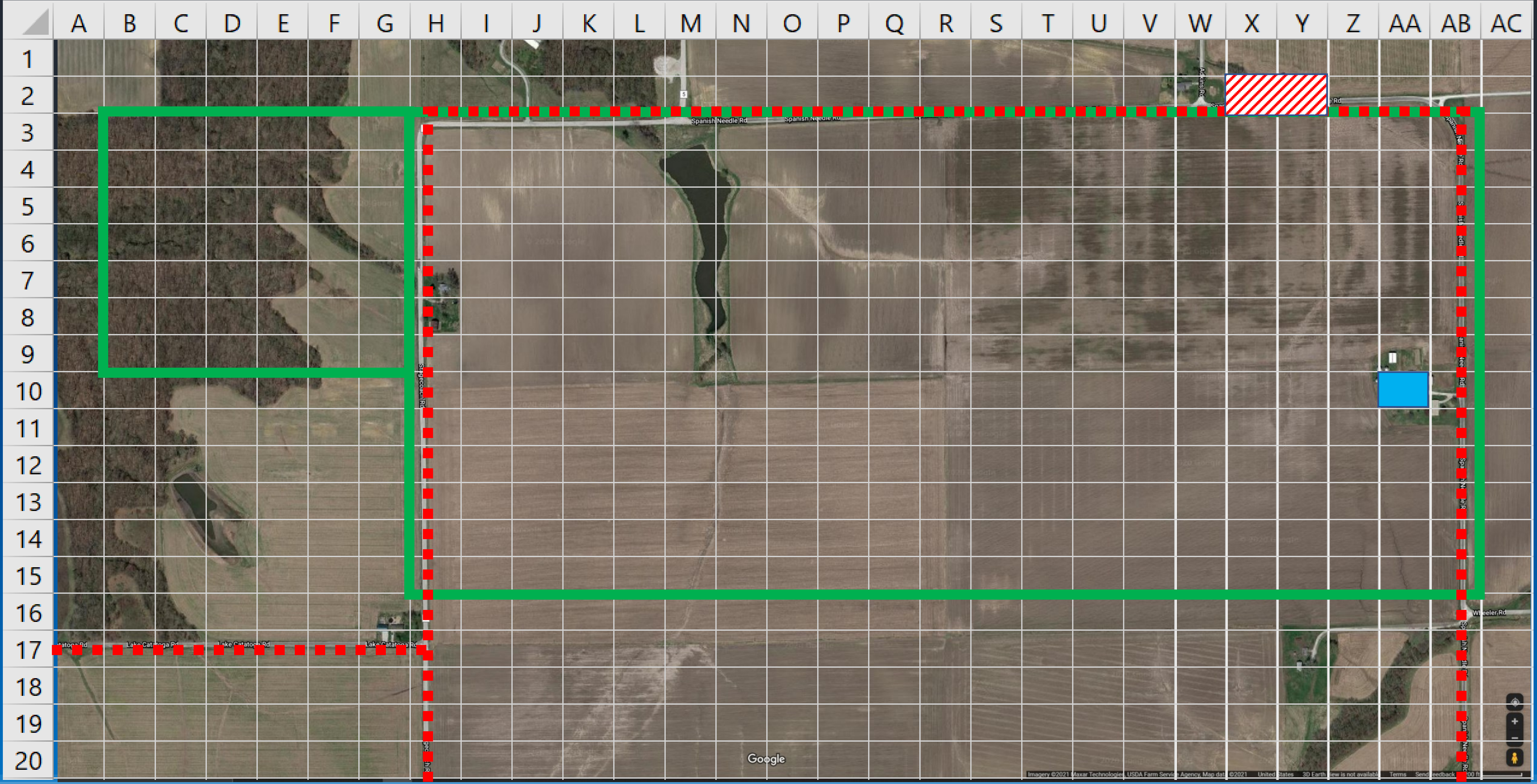

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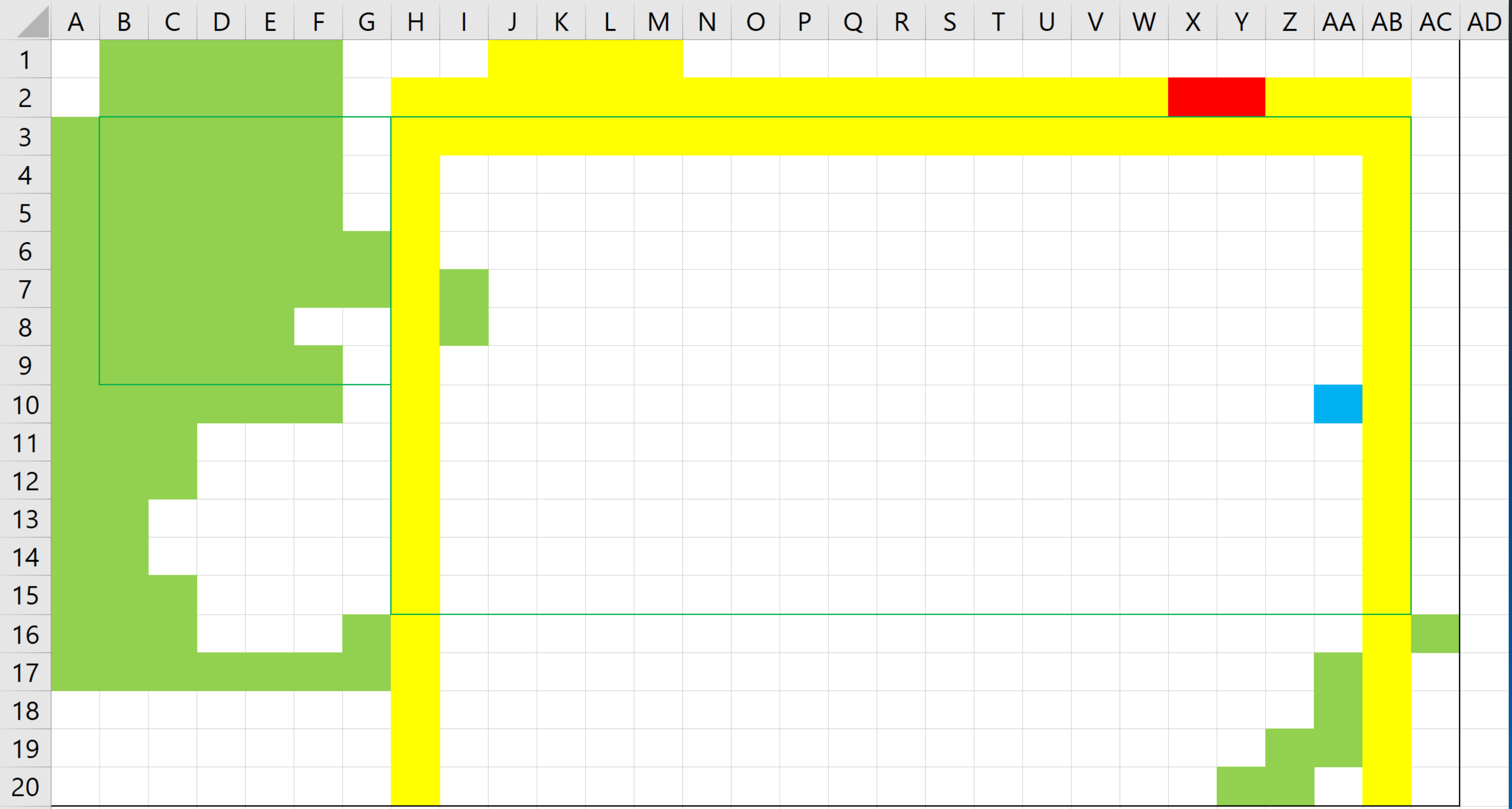

- No fly zone!
- COLLISION MARGIN required (200' minimum) for power line clearance
- COLLISION MARGIN required (200' minimum) for tree/forest clearance
- Start and End Point

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Here's the basic game… (Page 1 of 3)

- Objective: Visit all the squares inside the GREEN border.
  - Game 1: In the minimum amount of time
  - Game 2: Using the minimum amount of energy (thrust points)
- Initial Conditions
  - Start at AA10 at an altitude of 200 feet and a velocity of 100 fps in any direction you choose.
  - You begin the game with an energy budget of 500 “thrust points.”

Here's the basic game... (Page 2 of 3)

Direction	Distance (ft)
N	200
NE	283
E	200
SE	283
S	200
SW	283
W	200
NW	283

Move Name	Altitude Change (ft)	Velocity Change (fps)	Thrust Point Cost
STEEP-DIVE	-40	20	0.0
DIVE	-30	10	0.0
GLIDE	-20	-5	0.0
GLIDE-CRUISE	-10	-5	0.5
CRUISE	0	0	1.0
ACCELERATE	0	20	1.5
MAX-ACCELERATE	0	40	2.0
CLIMB	20	20	2.0
STEEP-CLIMB	40	0	2.0

- Rules
  - On each turn / step, direct the drone to move in a compass direction shown in the table. Note that diagonals are longer than ordinal moves!
  - Each step in your flight plan results in moving to a new square. To move to each new square, choose a move type from the table and calculate the impacts to Altitude, Velocity and Thrust Points.
  - Your path must return to AA10 to complete the mission. Your final altitude and speed can be any value within the constraints, and you can return from any cardinal direction.

Here's the basic game… (Page 3 of 3)

- Constraints:
  - At all times your drone must fly faster than 60 fps (to avoid stalling, resulting in an immediate crash and loss of the drone!) and slower than 200 fps (which is the current legal limit for an autonomous drone in the US).
  - At all times your drone's altitude must stay BELOW 400 feet (upper legal limit in the US).
  - Your drone's minimum altitude must stay ABOVE 100 feet (for the best camera image) OR above the collision margin (to avoid hitting obstructions).
    - Do NOT crash into the power lines or the trees! To go over these obstacles your altitude must be ABOVE 200 feet (e.g. this is the COLLISION MARGIN shown on the map).
  - Do NOT enter the RED AND WHITE HASHED AREA in the X2:Y2 area. EVER!
    (You CAN fly around it though, if all other constraints are met.)
  - Do NOT run out of thrust points. Remember that battery power is also needed for CONTROL! The minimum you can finish with is 1 thrust point – <u>not zero</u>.

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Output Format (Excel Compatible Please!) and Programming

Starting Location	Starting Altitude (ft)	Starting Velocity (fps)	Starting Elapsed Time (s)	Starting Thrust Points	Move Type	Move Direction	Ending Location	Ending Altitude (ft)	Ending Velocity (fps)	Ending Elapsed Time (s)	Ending Thrust Points
AA10	200	100	0	500	GLIDE	N	AA9	180	100	2.0	500
AA9	180	100	2.0	500	CRUISE	N	AA8	180	100	4.0	499
					…						
AA13	100	80	602.0	13	CLIMB	N	AA12	120	100	604.2	11
AA12	120	100	604.2	11	CRUISE	N	AA11	120	100	606.2	10
AA11	120	100	606.2	10	GLIDE	N	AA10	100	100	608.2	10

Preferred programming languages are Python, C++/C# and/or Java

Write the entire program in ONE language please!

Remember to DOCUMENT your drone's process…flowcharts are helpful here!

Don't just assume someone will "figure it out" later.

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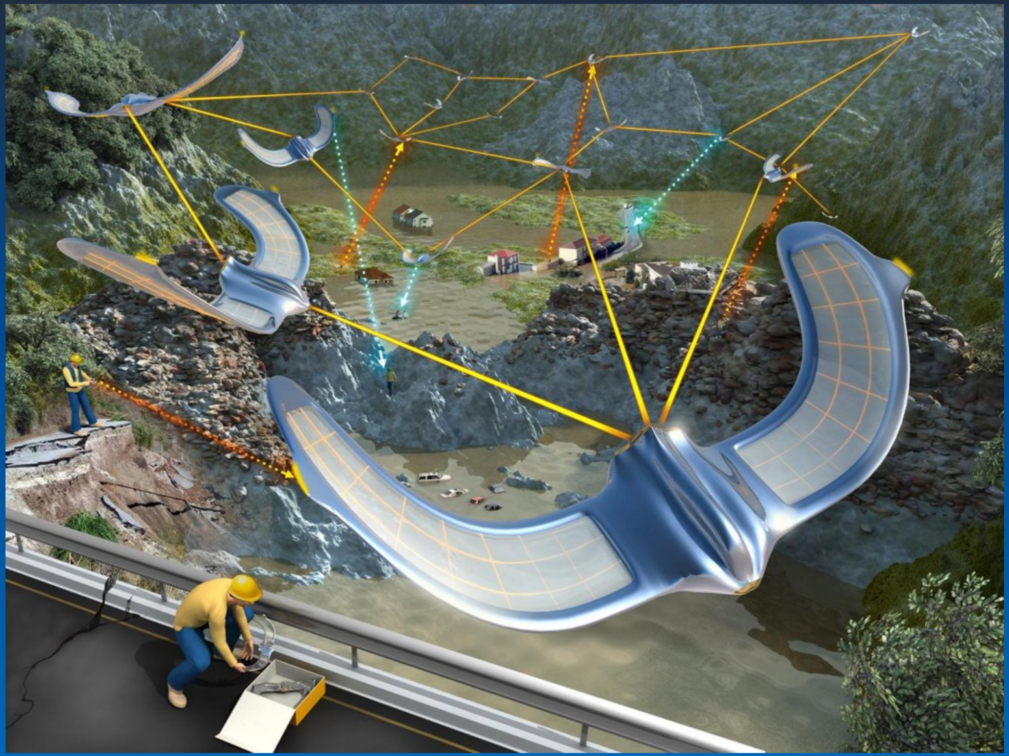
Adding more realism…

- Moving Hazards (Game 3)
  - Large birds and raptors may see the drone as a threat….and they WILL attempt to bring it down if it's in "their area." Red-tailed hawks like the one shown to left often dominate an area for their entire lifespan.
  - While the drone can outrun a raptor, it really can't outmaneuver it. Raptors can ALWAYS dodge a drone, so the drone is on defense and the raptor is on offense!
  - To start, the raptor will be in a tree or a high position. This could be any of the yellow squares on the map, chosen at random at the start of the game. The raptor will start at 100' altitude and 160 fps velocity.
  - On every move the raptor will move toward the drone's ENDING position (because they're smart like that). On the attack the raptor always moves at a constant rate of 160 fps. It can change its altitude UPWARDS at 20 fps or DOWNWARDS at 160 fps. (They dive much faster than they climb.) As far as this game is concerned, the raptor has no upper altitude limit (some have been tracked as high as 14,000'!).
  - For purposes of this game, raptors ALWAYS ATTACK FROM ABOVE. If the raptor and the drone finish their moves in the same square AND the raptor is ABOVE the drone AND it can dive fast enough to catch it, the raptor will kill the drone and it's game over for us. (Look at those talons!) If the raptor is in the same square and it can't close the gap in one turn, it will dive as close to the drone as it can. (Next turn is not looking good for the drone at that point.)
  - Finish the mapping in the minimum amount of time, without running out of energy, and without the raptor killing your drone!

Adding more realism…



Source: https://www.nbcnews.com/tech/innovation/drone-swarms-could-be-lifesaver-disasters-n15906

- Multi-Drone Coordination (Game 4)
  - Multiple drones may work an area together, but then they need to AVOID each other. Assume they have some type of communication mechanism to allow them to coordinate movements.
  - Birds always attack the drone closest to them. If two or more drones are equidistant then the raptor will choose one at random.
  - Any drone will perform an EVASIVE ACTION if they come within one square of another drone or a bird. (Read: If you draw 1 square a box around a DRONE and there's a BIRD or a DRONE in it, take an immediate EVASIVE ACTION.)
  - EVASIVE ACTION automation will command the drone to maintain altitude and velocity, while causing it to turn RIGHT 90 degrees immediately and stay in the new direction for one more square. EVASIVE ACTION takes precedence over all other commands, even if this causes a collision or runs the drone out of energy / thrust points.
  - Survey all the squares in the least TOTAL energy points (sum of all drones). You can use up to 10 drones simultaneously.

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Adding more realism…

- Wind (Game 5)
  - Wind can come from any half-cardinal direction (N, NE, E, SE, S, SW, W, NW) and at any speed.
  - Wind increases or decreases your SPEED and changes your DIRECTION based on trigonometry between your drone's velocity vector and the wind velocity vector.
  - Remember that the wind will push you sideways if you're not careful. To maintain a straight line with a side wind, sometimes you have to "crab" into the wind and add thrust (using precious thrust points).
  - Flying into the wind can allow you to CLIMB more feet upwards for the same energy with the same increase in ground speed – but CRUISE into the wind becomes more expensive and GLIDE loses more speed for the same drop in altitude. Flying downwind does the exact opposite of these.
  - Wind affects all drones the same way when multiple drones are in the air.
  - Wind also affects birds in similar fashion to drones.

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