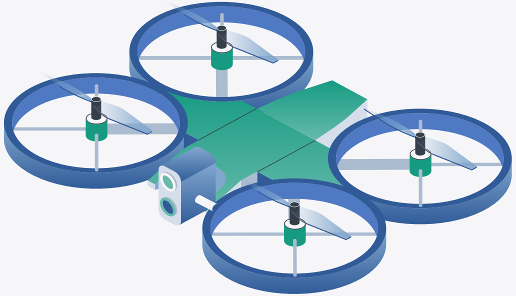
AERIAL DRONES Missions With 5G And Starlink Support

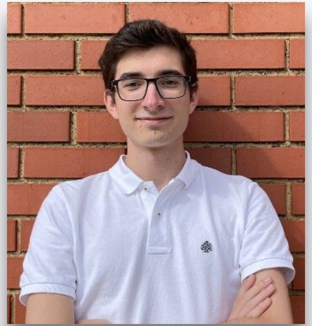


António Almeida, Francisco Ribeiro, Guilherme Vieira, Miguel Vila, Tiago Rodrigues

WHO ARE WE?

António Almeida

Francisco Ribeiro



Guilherme Vieira

Miguel Vila

Tiago Rodrigues

SUPERVISORS

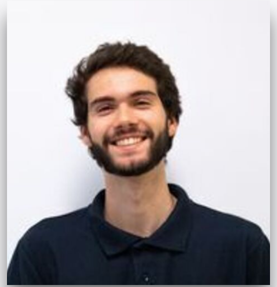
Susana Sargento

Pedro Rito

Joaquim Ramos

Diogo Correia

Marcos Mendes



Pedro Valente

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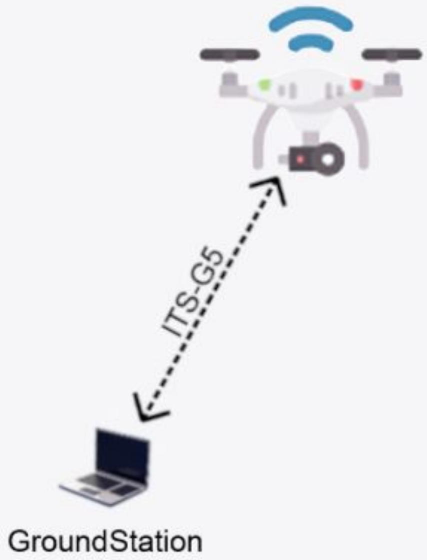
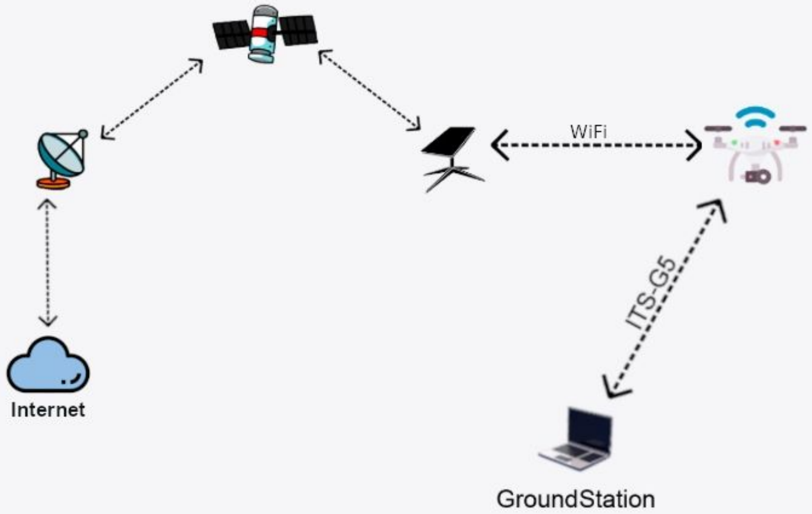
OUR PROJECT

STARTING POINT



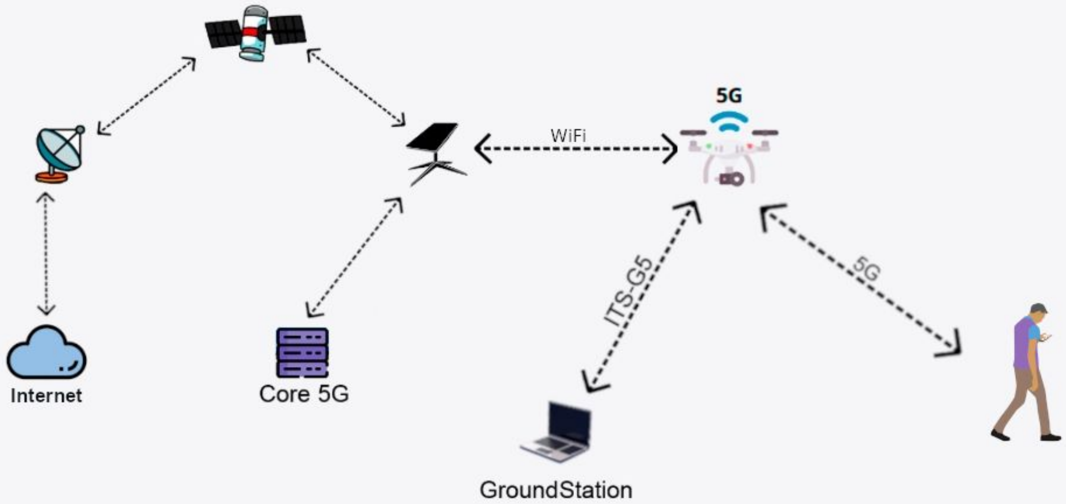
OBJECTIVES



Starlink

Connecting the drone to the internet using a Starlink access point.

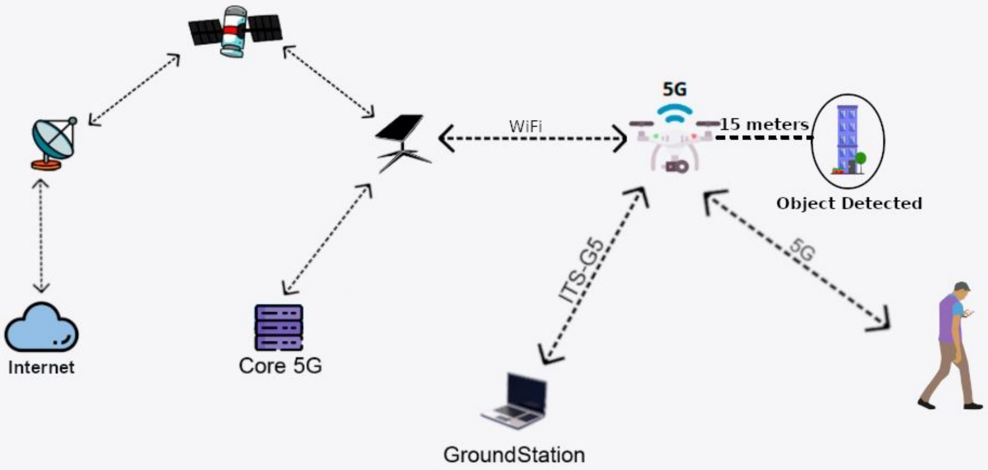
OBJECTIVES



5G Connection

Providing a reliable 5G connection to the end-user.

OBJECTIVES

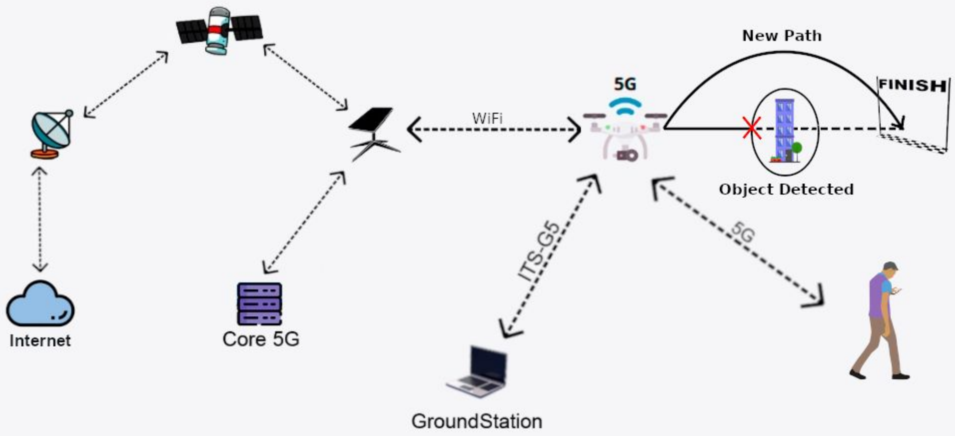


Camera

Determine the distance of points in front of the drone

Send information to the GroundStation through ITS-G5 using HTTP

OBJECTIVES

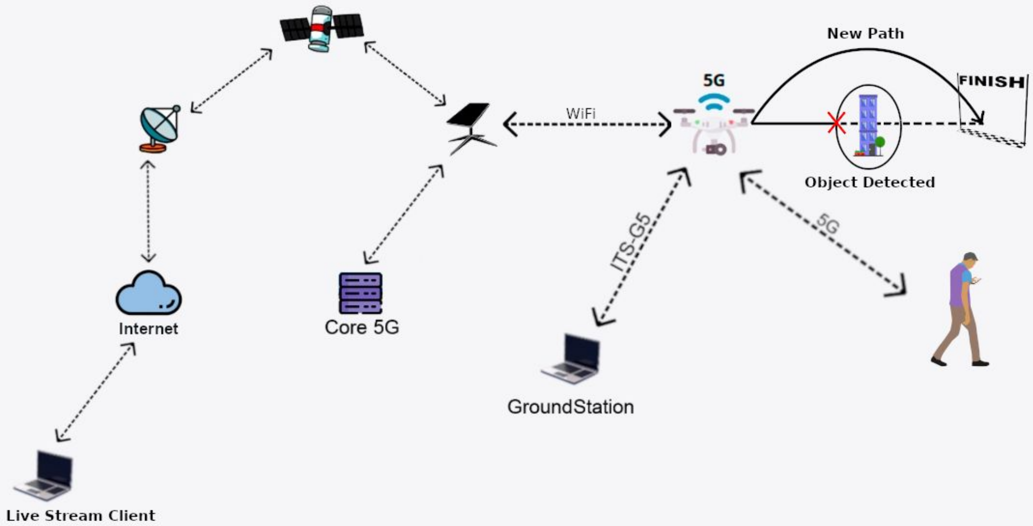


Obstacles avoidance

Create an autonomous way to change the course depending on the surrounding environment

Detecting the obstacle in time to dodge
Total Drone weight with all sensors on board
Integration of the values received from the camera in the mission

EXTRA FUNCTIONALITIES

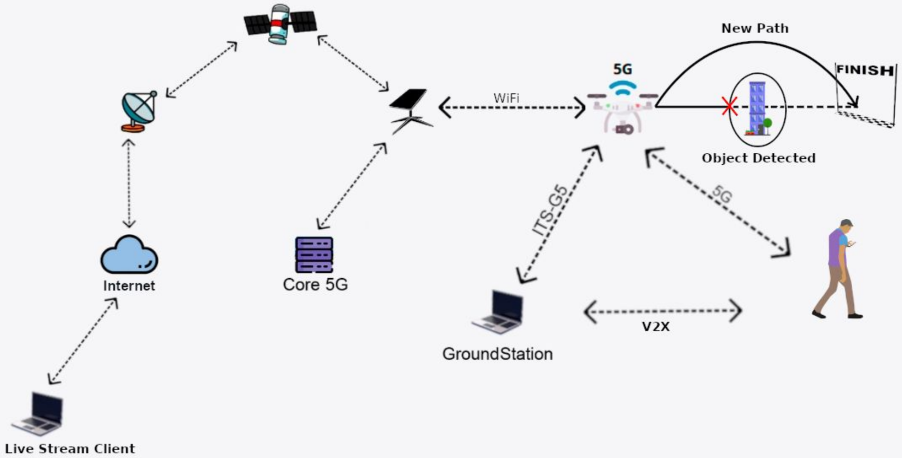


LIVE FEED

Give the ability to see what the drone sees in real time.

- Consuming raw camera feed;
- Making two processes consume the same video feed.

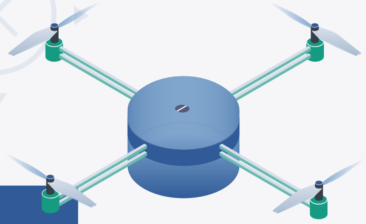
EXTRA FUNCTIONALITIES



FOLLOW MISSION

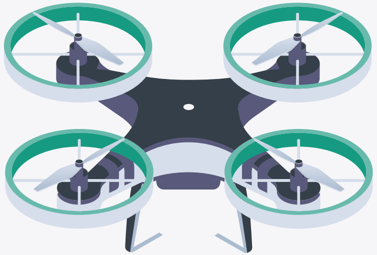
Use an app that sends the GPS of the end-user to a mission running on the drone.

The end-user always needs an active internet connection to send the GPS data.

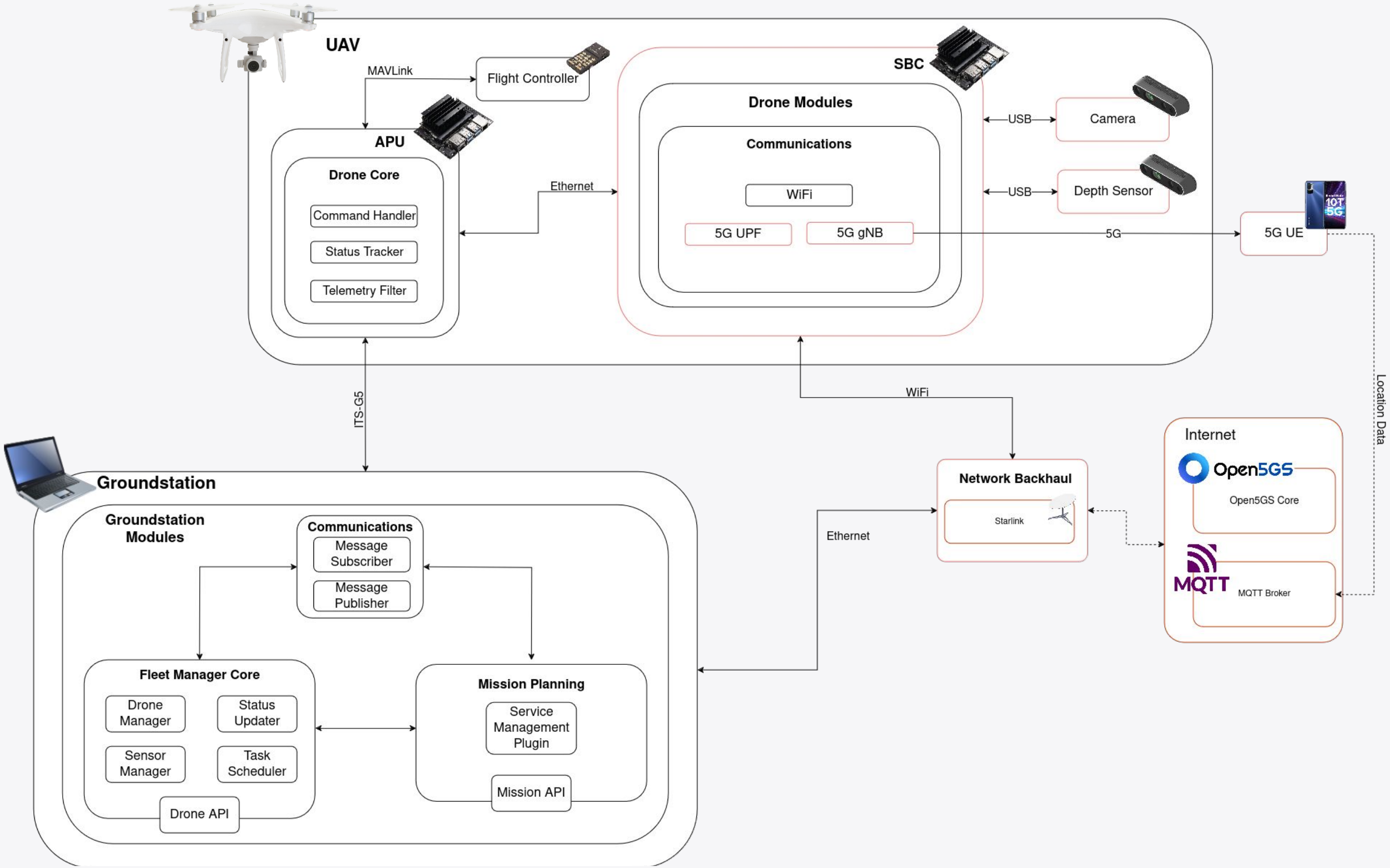


02

THE PATH TO OUR GOAL



ARCHITECTURE



OUR DRONE

USRP

Jetson

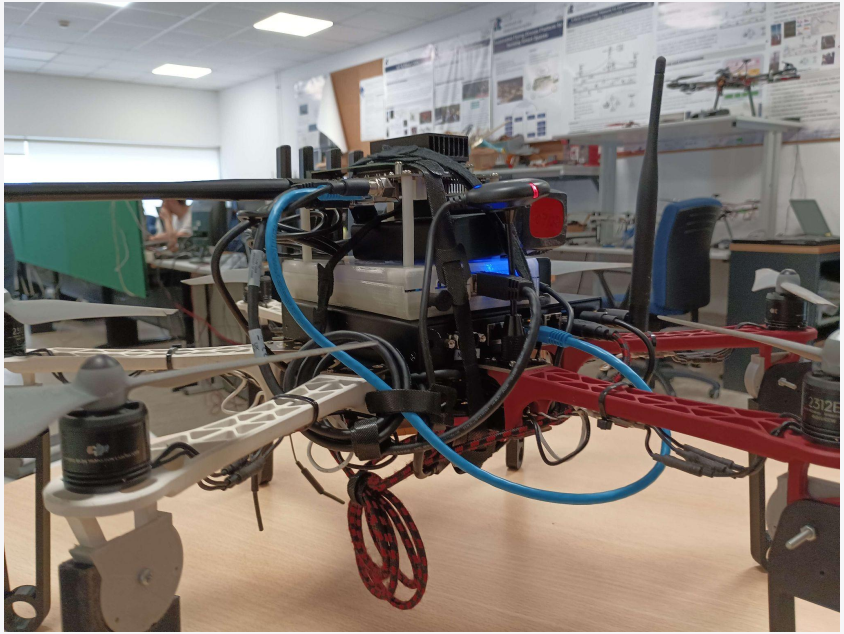
Camera/
Depth Sensor

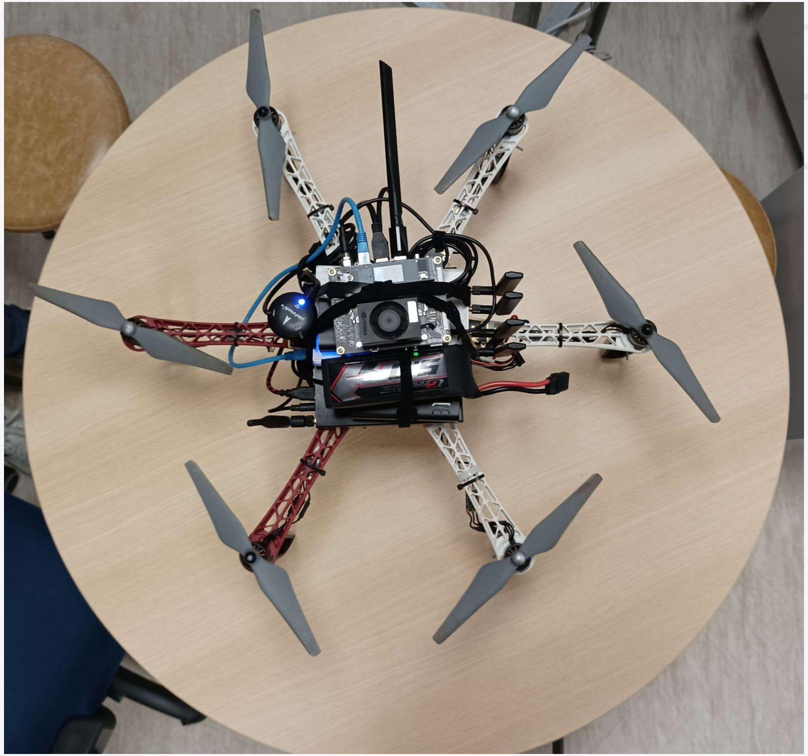
Powerbank

APU

Battery

OUR DRONE





NETWORK

5G Connection

Creation of a private 5G network to provide connectivity to the end-users.

Starlink

Use a Wireless Adapter connected to the Jetson to provide the backhaul link.

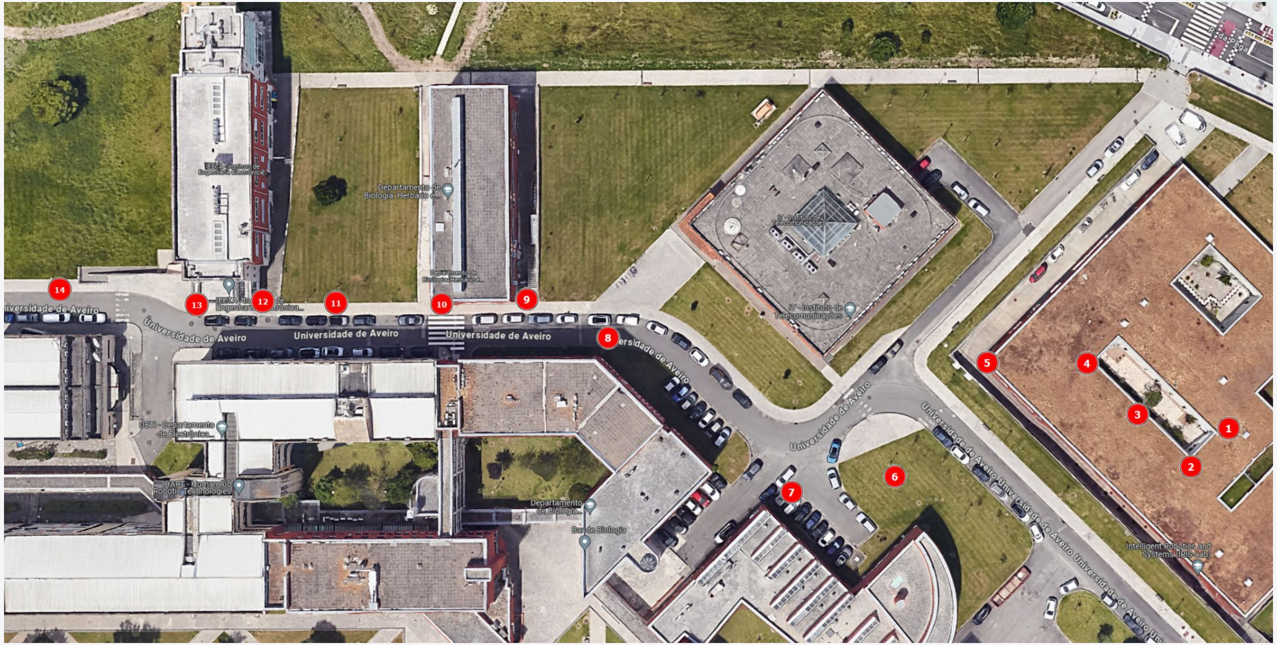
STARLINK PERFORMANCE - RESULTS

	Download (Mbps)	Upload (Mbps)	Latency (ms)
Min	165.04	26.26	28.17
Avg	255.64	41.10	30.03
Max	331.84	53.02	33.90

Metric	Mean	Standard Deviation	Confidence Interval (90%)
Download Speed	255.63	30.912	(189.738, 321.536)
Upload Speed	41.09	4.684	(31.113, 51.085)
Latency	30.03	1.572	(26.681, 33.385)

The speedtest was performed using the speedtest-cli tool from the NUC directly connected to the Starlink router via a 1Gbps NIC (network interface card).

BACKHAUL WIFI - RESULTS



Tests performed using iperf3. A NUC, as a server, with a 1Gbps NIC directly connected to the StarLink access point. The client was a Nvidia Jetson Orin connected to the same access point via a Archer T3U Plus dual band wireless adapter over USB 3.0.

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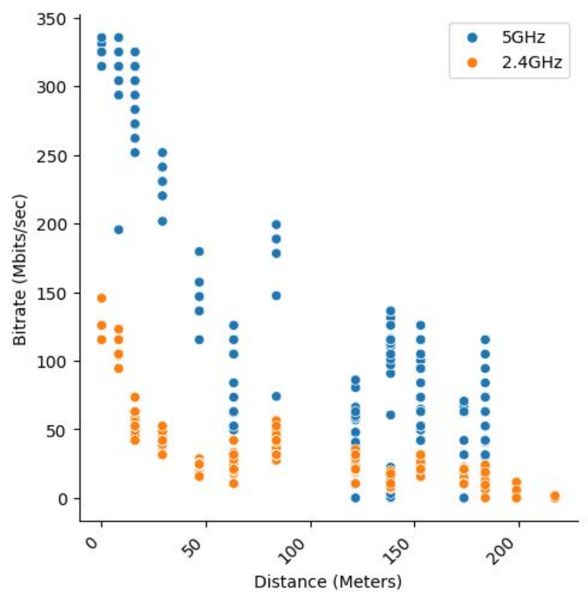

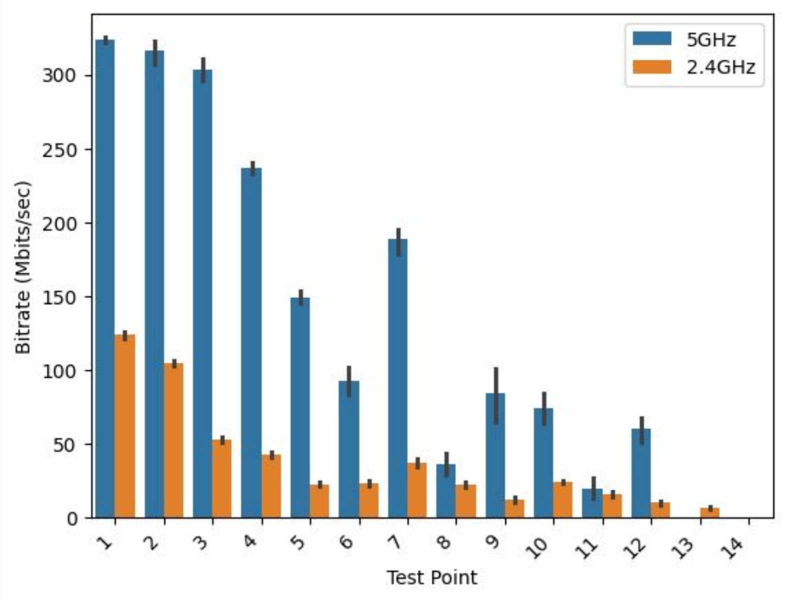

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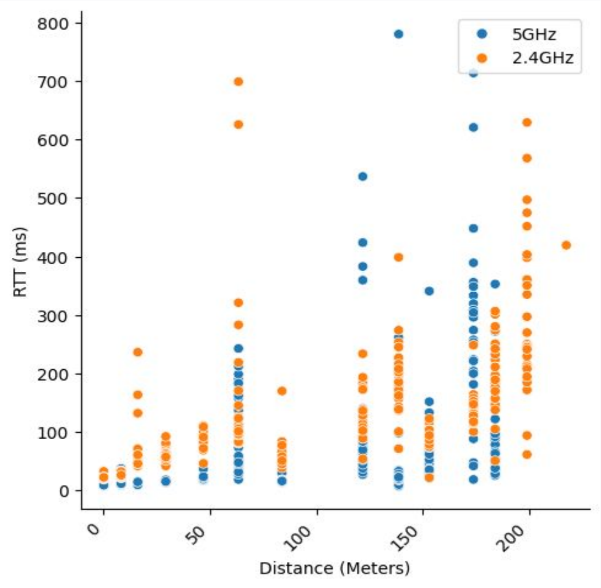

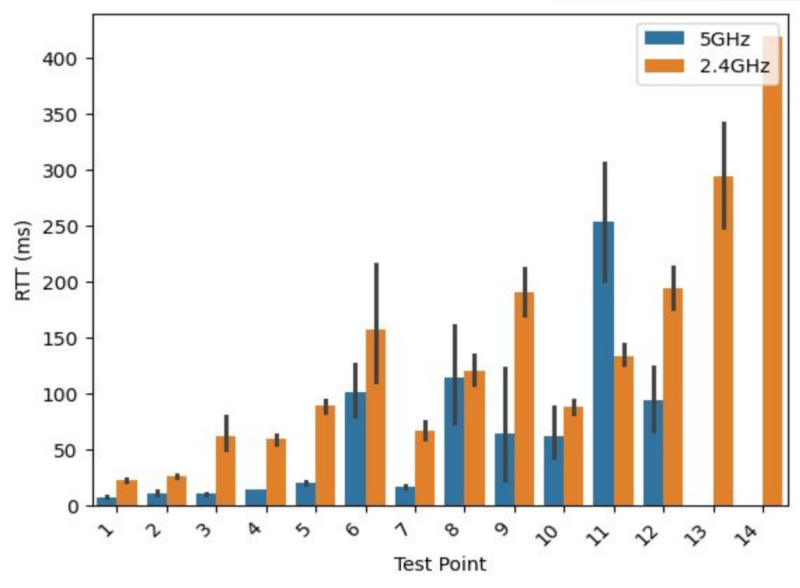

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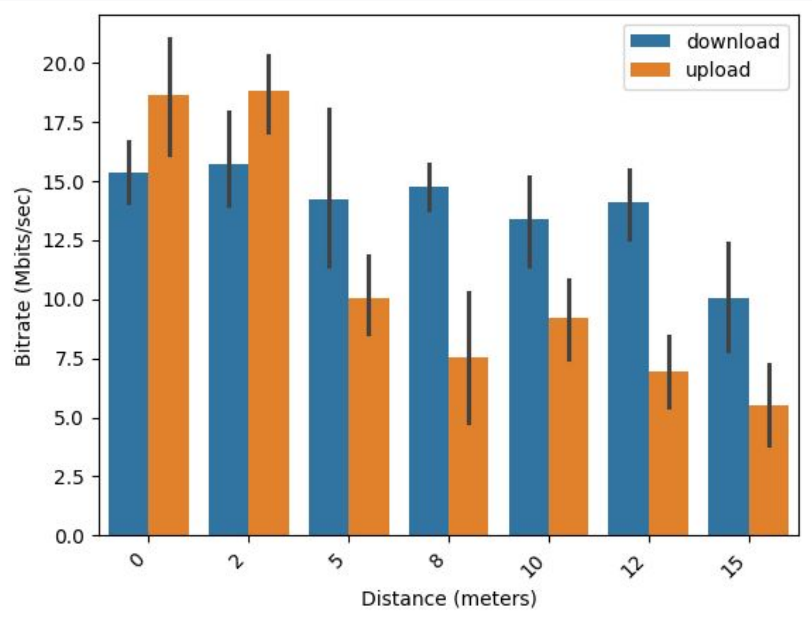
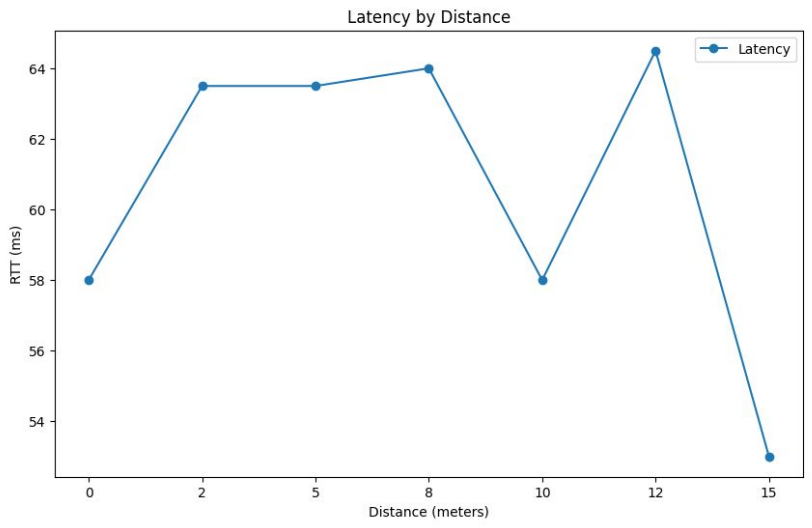
5G UPF - RESULTS



These tests were performed using iperf (upload / download) between the UE (Google Pixel 6a) and the UPF container on the NUC over the 5G network at different locations.

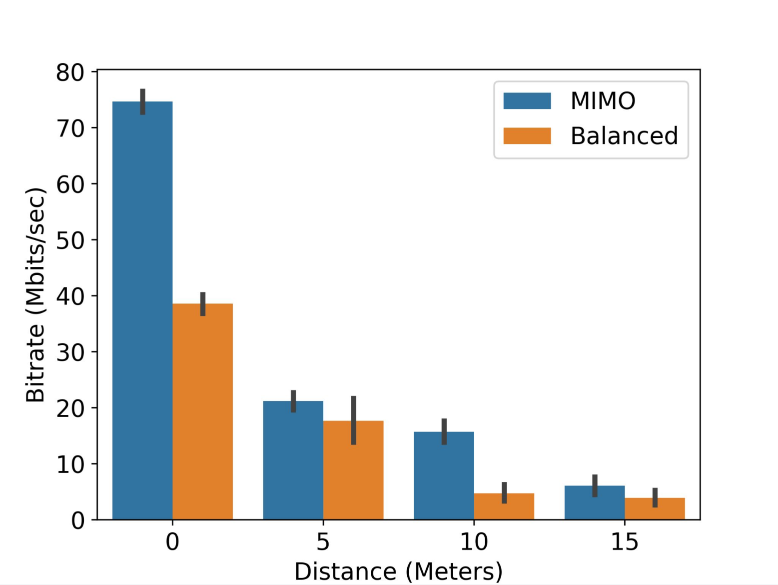
5G SPEEDTEST - RESULTS



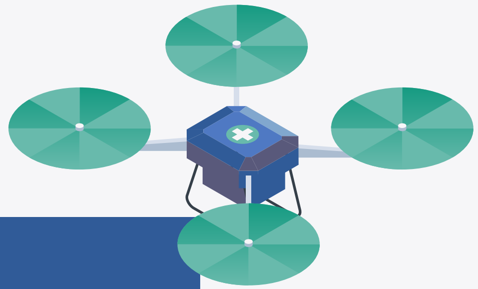
The speedtest was performed using the speedtest-cli tool from the UE (Google Pixel 6a) connected to the private 5G network broadcasted by the Jetson Orin's USRP.

5G - What happened here?

- The NVIDIA Jetson Orin is the main culprit;
- NVIDIA Jetson Orin:
  - Excels in graphics-accelerated intensive tasks;
  - Not well-suited for CPU-intensive tasks, such as those handled by a gNodeB.
- A NUC can be way more powerful and give out better results;
- Running a live feed script, object avoidance script, and gNodeB concurrently, leads to a significant performance degradation.



Iperf3 test from a setup with a NUC and a better radio configuration.



MISSION

A mission to rule them all

ALGORITHM

- **Create a circle...**

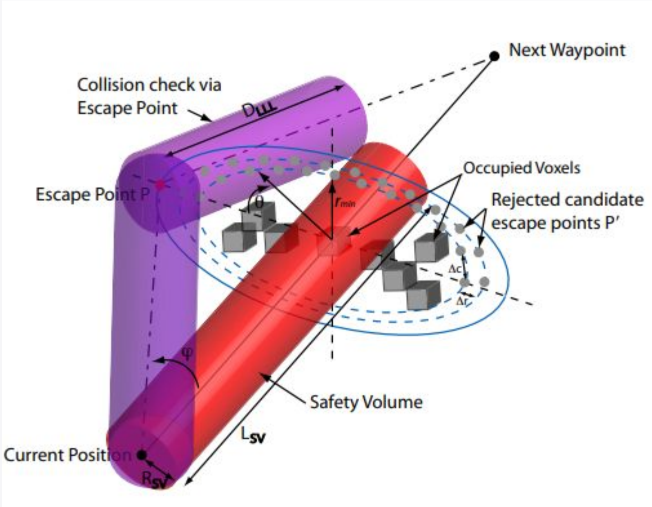
  ...with a radius bigger than the drones dimensions

- **If it needs to dodge...**

  ... it will move the circle right and left trying to find an Escape Point

- **Send Information...**

  ...to the groundstation, in an array, to dodge [Flag, angle, movement]



Images taken from: https://ieeexplore.ieee.org/abstract/document/6094629/metrics#metrics

ALGORITHM, PAUSE MISSION

- **Send Information**

  Send the information through Ethernet to the Drone's APU

- **Pause Mission**

  Send a POST request to the Groundstation with the pause command

- **Dodge**

  Use the information to create a mission to dodge and send the mission through a POST request

- **Resume mission**

  When the dodge mission is finished send a POST request to the Groundstation with the resume command

LIVE FEED

Camera

Create a Python Script that uses the Intel RealSense Library on the Jetson to capture the color feed of the camera.

WIFI

Send the information in a P2P, using sockets, through WIFI connection between the Drone and the Client.

FOLLOW A PERSON

- **Publishing the coordinates**

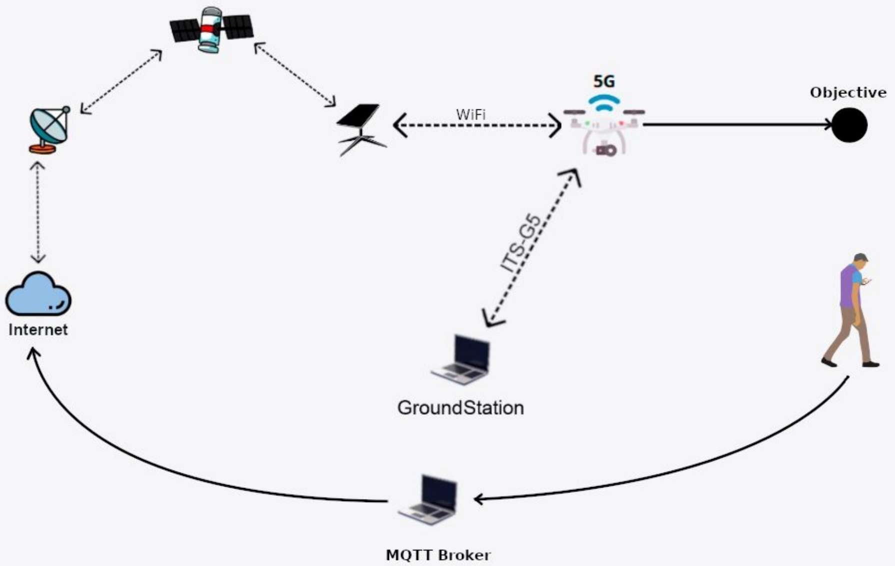
  Using VAMs to publish the coordinates to a MQTT broker

- **Informing the drone**

  Sending this coordinates to the drone as a sensor information

- **Go to the coordinates**

  Go to the person's coordinates, keeping a safe distance



03

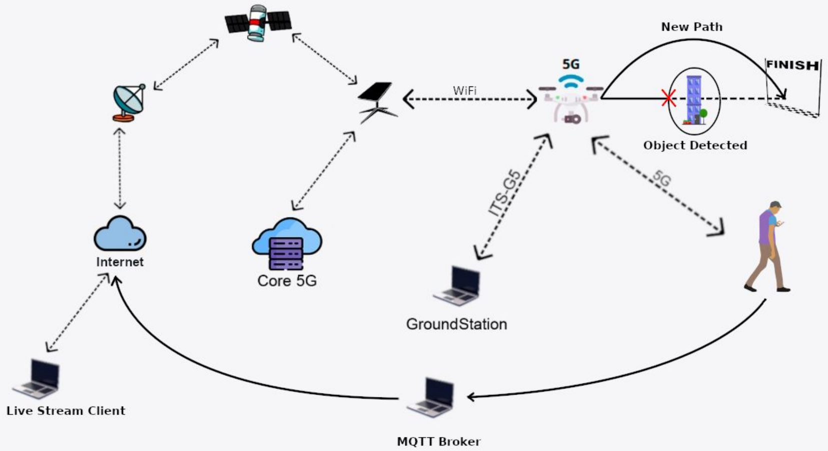
CONNECTING THE DOTS

CONNECTING THE DOTS

Send the mission to the Drone which is connected to the Starlink with path to the 5G Core.

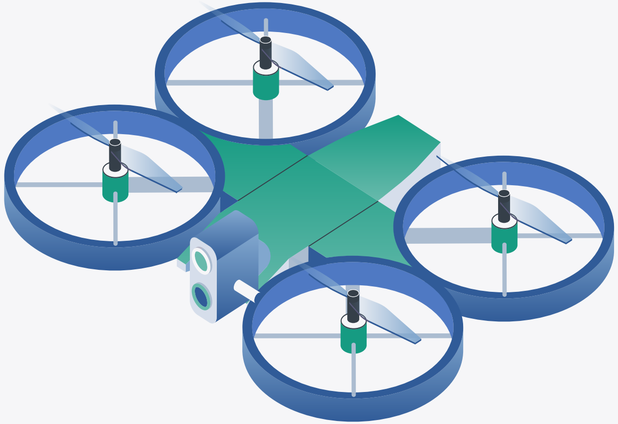
Drone will Dodge if needed, it will send commands through ROS2

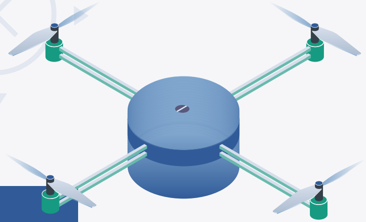
The Drone will always be sharing a 5G connection in the area



04

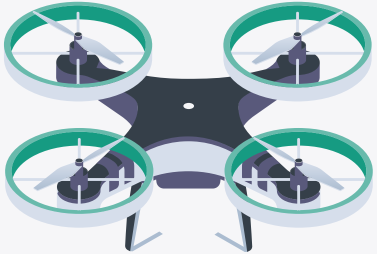
Demonstration

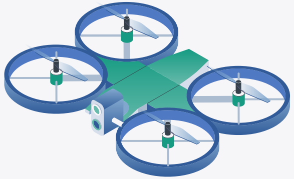




05

WHAT WE HAVE LEARNED





WHAT WE HAVE LEARNED

Conclusion

Done all the major objectives with room to some minor too:

- Integrate 5G, satellite and WiFi communications in drones;
- Drones as mobile 5G base stations;
- Autonomous drones missions
- Object detection, object avoidance
- Person following through app communication
- Live feed

Challenges:

- Connecting many different technologies
- More specific:
  - Cuda
  - The development of a way to pause missions.
  - Kernel
  - The weather

What could be changed?

We could change the hardware in order to improve the 5G performance

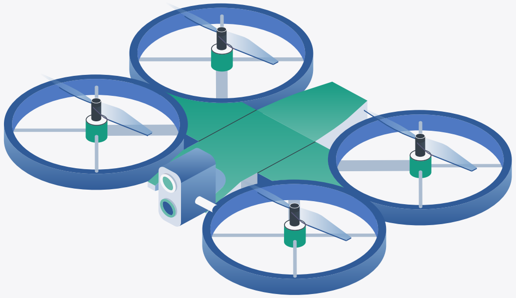
06

FUTURE WORK

FUTURE WORK

- Build a network integrating multiple drones;
- Implement object detection capabilities using Yolo;
- Following a person using object detection;
- Continue the development of communications making them more reliable and flexible.

AERIAL DRONES Missions With 5G And Starlink Support



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