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ALPAGA : An AeriaL Platform for sampling Atmospheric Gases and Aerosols

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OVERVIEW

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CHAPTER 1
INTRODUCTION

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Context:

- CERI « Système Numérique » and « Energie et Environnement »
- Knowledge on air quality measurement and development of multi-agent mission (mapping, communication, …)
- Autonomous drone for sampling atmosphere and mapping widely spread in the scientific community

Motivation:

- Unknown around climate change and global warming
- Monitor the pollution and analyze the air quality (Volatile Organic Compounds)
- Complex to sample a large volume of air

- UAV are now common but their use in a fleet is still a challenge
- Create new method and algorithm for the fleet in order to complete a mapping mission

Objectives : Build a robust multi-drone fleet to autonomously map atmospheric volumes

Problematic in the point of view of the atmospheric scientists :

- Analyze air quality require heavy and power consuming sensors
- The wrong sampling method can distort the air quality
- Need for a minimum quantity of air to sample

- How to design an embedded sampling system to collect an air volume without adding disruptive component ?

Problematic in the point of view of the robotic scientists:

- Scale a sampling system to a fleet in order to construct a map is a complex task
- Establish algorithms and architectures to build a fleet which can complete collaborative missions

- What architecture must be set for the fleet to communicate, schedule UAV's actions and let the fleet autonomously succeed its mission?

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CHAPTER 2
DESIGN OF A SAMPLING SYSTEM

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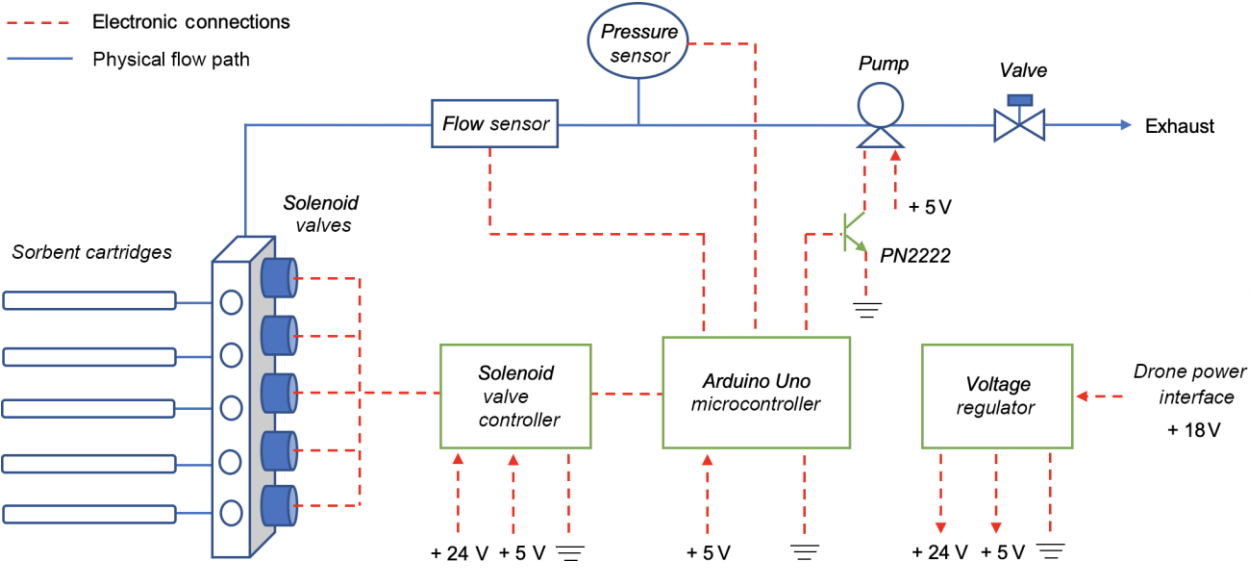
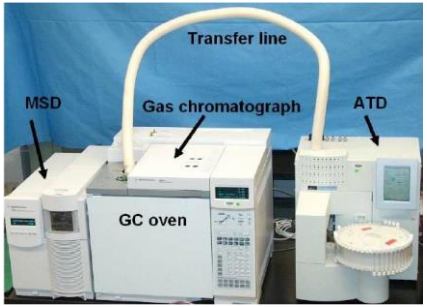
[1] K. A. McKinney *et al.*, “A sampler for atmospheric volatile organic compounds by copter unmanned aerial vehicles,” *Atmos. Meas. Tech.*, vol. 12, no. 6, pp. 3123–3135, Jun. 2019, doi: 10.5194/amt-12-3123-2019.



Tube system not completely satisfying:

- Collect a sample is quite long (few minutes for one sample)
- Complex to clean tubes once used
- Other methods not existing
- Creation of an innovative method would allow comparison between them



Design of a new sampling system:

- Use Tedlar Gas Sampling Bags instead of Tube
- Objective to fill the bag without including disruptive air component
- Blowing air directly to the bag will add air pollution from the pump that have to be avoided

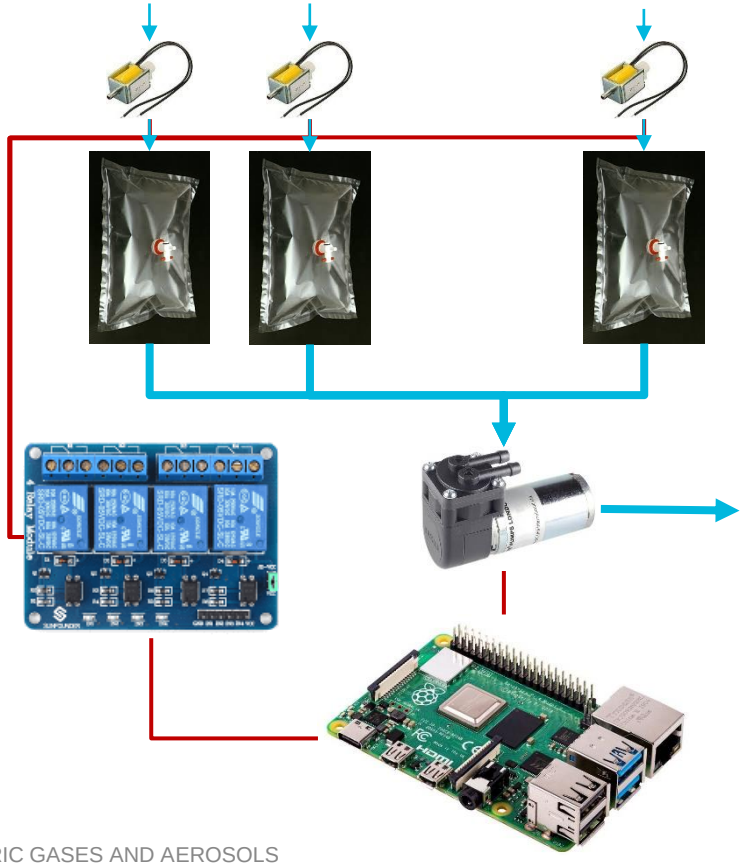
- Trigger a sample become something more complicated

Trigger a sample to fill a bag:

- Create a depressure inside a specific container where the bag will be placed
- Open the bag input to fill it with air
- The inflation time will only depend on the pressure difference between the outside and the container

The architecture of the sampling system:

- Creation of a depressure with an embedded pump
- Use electro valve to fill the bag when desired
- Trigger the measure with relay that will open the electro valve
- Every component is supervised by a Raspberry Pi 4



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CHAPTER 3
INTEGRATION INTO THE UAV

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Specifications of the DJI Matrice 600 Pro :

- Hexacopter with 21” propellers
- Dimensions: 1668 mm × 1518 mm × 727 mm
- Weight: 10 kg without payload // 15,5 kg max
- Max speed: 18 m/s without wind
- Autonomy: 6 battery 6S 4500 mAh → between 16 to 32 min
- Max range: 3 km
- 3 GPS Unit
- Automated retractable landing gear

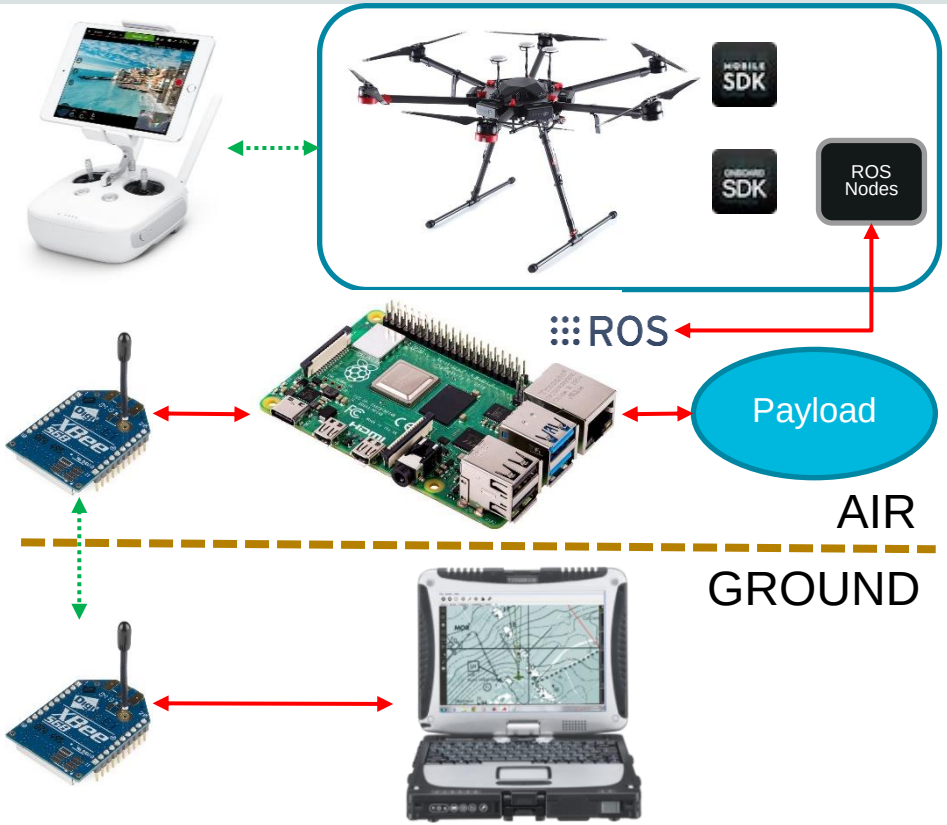
→ Perfect drone to embed heavy payload

Transform a commercial drone into an UAV :

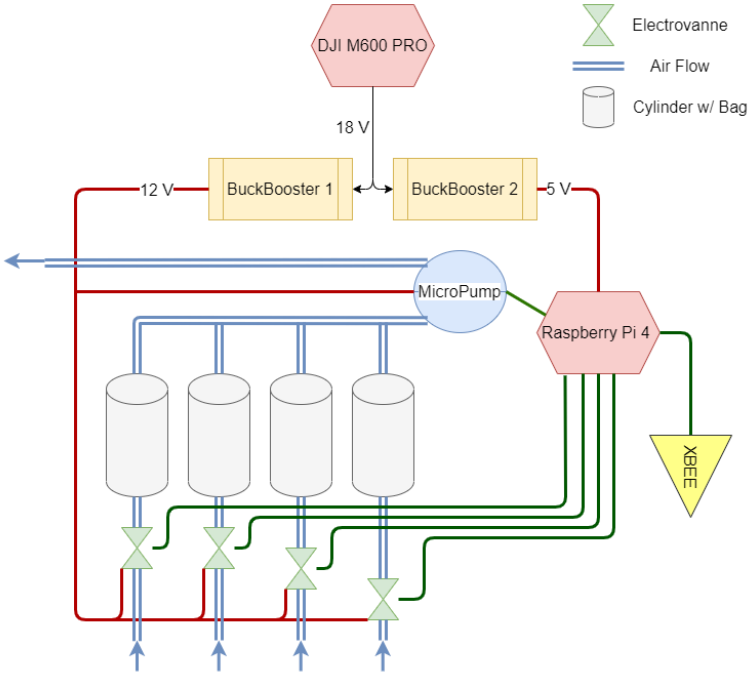
- Pilot DJI application already existing
- M600 Pro propose an Onboard SDK and a Mobile SDK
- OSDK comes with ROS functionalities
- Add a third-party computer to interact with the Flight Controller

Communication Ground/Air:

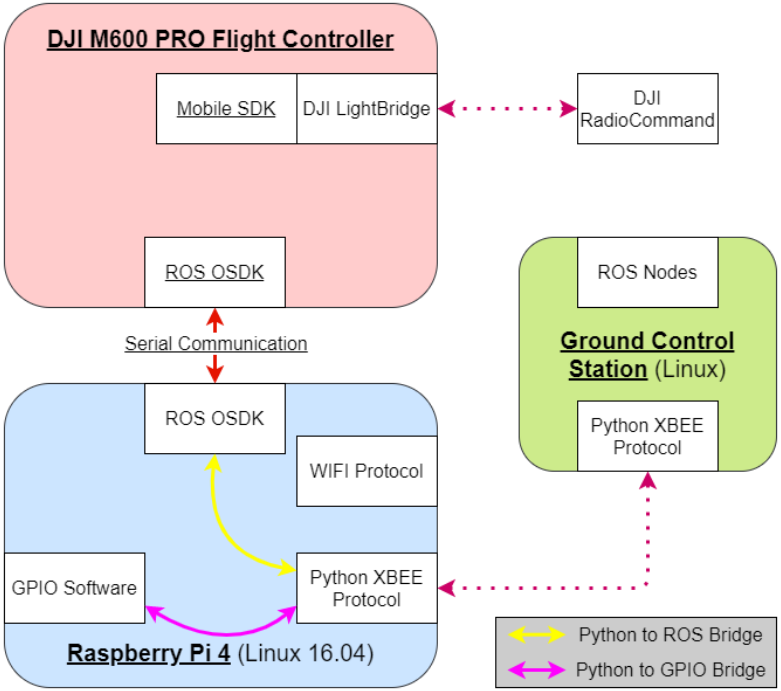
- XBEE module embedded and for the Ground Control Station
- Satisfying range
- Use different network architecture
- Easily scalable and well documented



Hardware architecture:



Software architecture:



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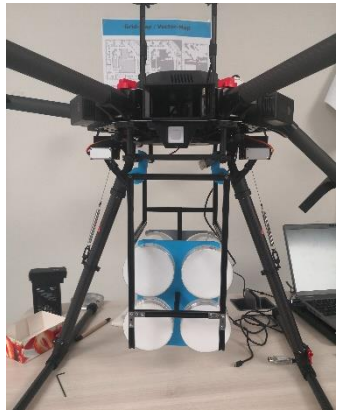


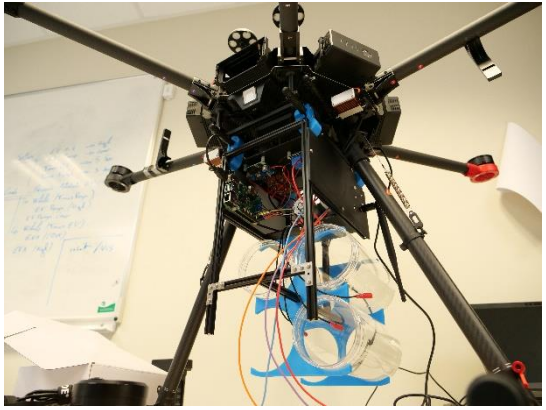

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CHAPTER 4
THE FUTURE OF ALPAGA

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Interesting topics:

- Attitude of the drone
- GPS and local position
- Height above take off
- Velocity
- Different camera sources

Propose a mission mode:

- Missions planification
- Use of Waypoints to set specific trajectories
- Possibility to create complex behavior

Evolution on the different payload :

Cartridge tube system:

- Set the system to be trigger by the drone
- Geolocalize the sample

Bags system:

- Create better airtight container
- Embed more bags for one flight
- Analyze and compare both system

Objectives to develop an entire fleet :

- Combine different method of sampling
- Create complex communication network
- Elaborate collaborative strategy and distributed algorithms

Conclusion:

- Work in progress
- Result of the first flight test encouraging
- Payload almost finished
  → flight test will start soon
- Interconnection between RPI4 and the DJI OSDK set
  → development of new complex behavior possible

Thanks for your attention !

I’m available for your different questions !

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