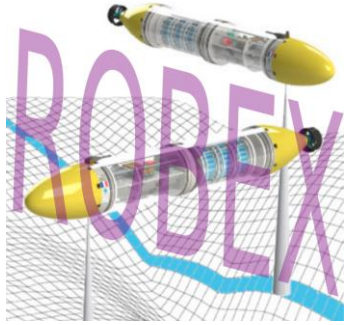
ISEN OUEST

4th RobEx Day



L@B ISEN

PeliKwad: air-water drone deployed at Dronathlon 2024

Dr. Henrique FAGUNDES GASPAROTO (Mechanics - Robotics)
Dr. Titouan VERDU (Robotics - Drones)

DRONATHLON

MARINE NATIONALE

AGENCE INNOVATION DÉFENSE

DGA

DÉPARTEMENT Finistère Penn-ar-Bed

L@bISEN | An Overview

- Research and innovation laboratory of ISEN School of Engineering
- Common research project: **Smart and autonomous systems**
- Academic and industrial research

Figures as of 31/12/2023

1 research laboratory on **5** campuses

100 members

54 lecturers researchers

5 research engineers and technicians

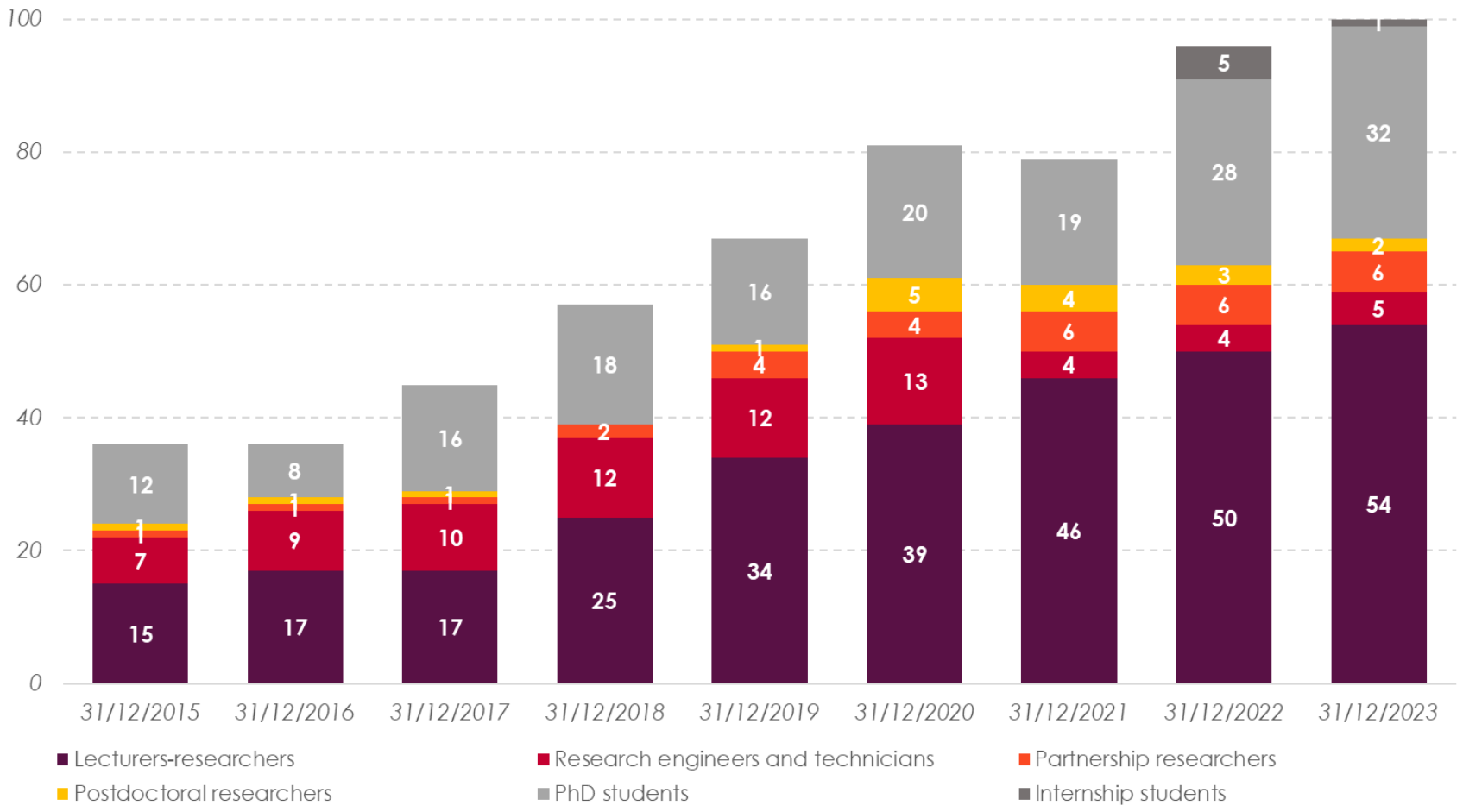
2 postdoctoral researcher

32 PhD students

6 partnership researchers

1 internship student

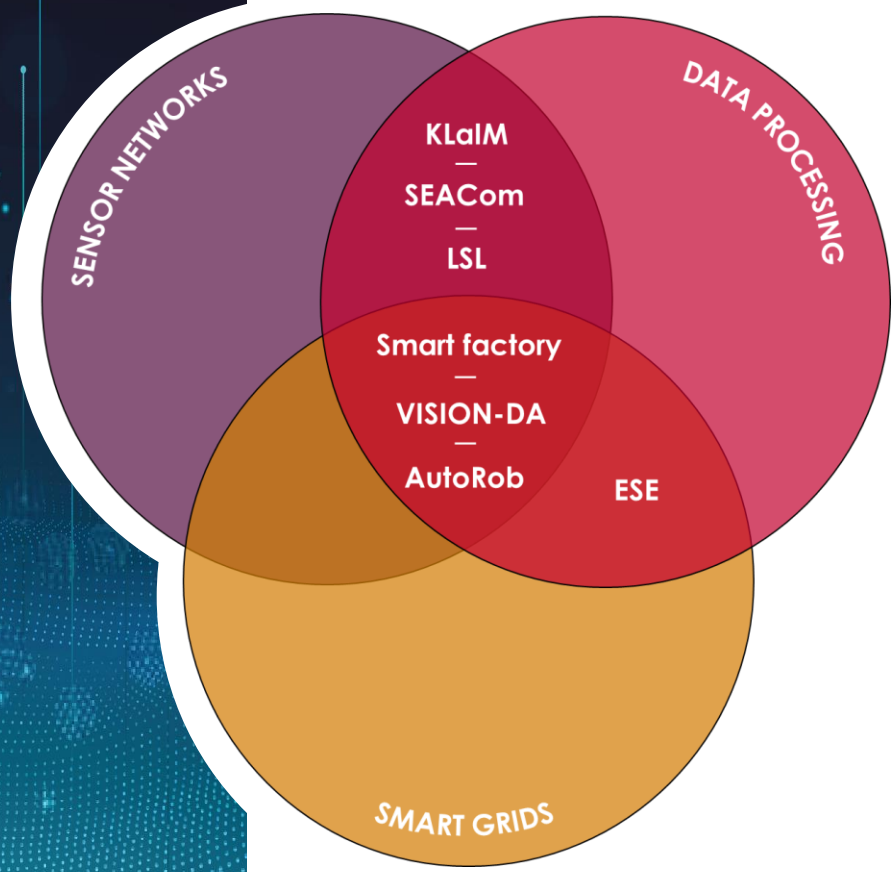
L@bISEN | A Fast-Growing Unit over the 2015-2023 Period



Staff development at L@bISEN since 2015

As of 2023, 8 L@bISEN lecturers-researchers are entitled to fully supervize PhD theses.

L@bISEN | Research Teams and Platforms



RESEARCH TEAMS

- AutoRob – Autonomous Robots
- ESE – Energy and Electromechanical Systems
- KLaIM – Knowledge Learning and Information Modelling
- LSL – Light - Scatter - Learning
- SEACOM – Embedded Systems, Acoustics and Communication
- SFact – Smart Factory
- VISION-DA – Vision and data analysis

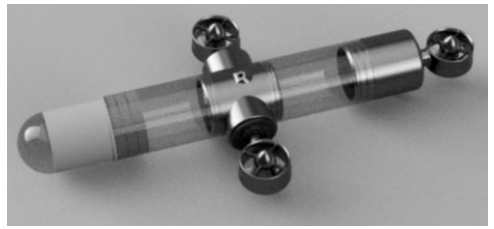
L@bISEN | Autonomous ROBots Team (AutoROB)

- **Team leader:** Henrique Fagundes Gasparoto (henrique.gasparoto@isen-ouest.yncrea.fr)

- **Team research project:**

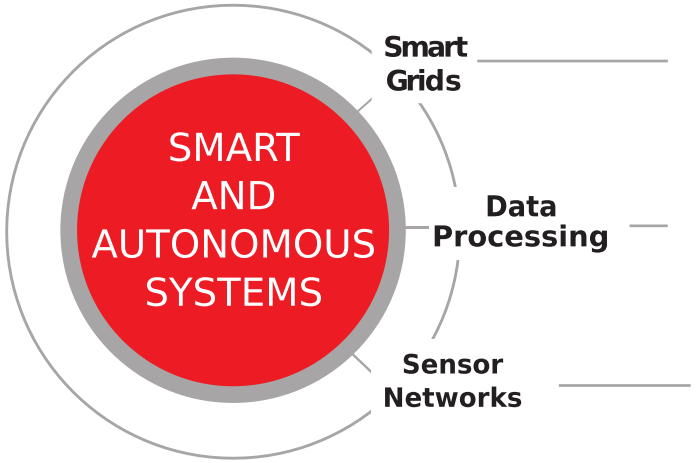
Conception and coordination of fleets of autonomous, hybrid and reconfigurable robots for the realization of complex tasks.

- **Main subjects:**
  - Architectures of hybrid and reconfigurable autonomous robots
  - Algorithms for the coordination of autonomous robots
  - New actuators for reconfigurability

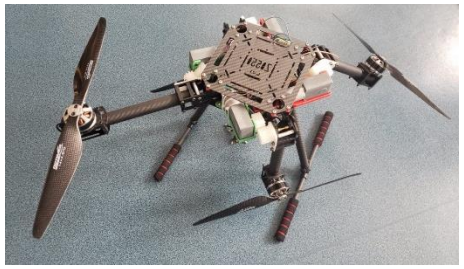


RUR (Reconfigurable Underwater Robot)

- **Activités de recherche principales :**



- **Adaptation to the environment**
- **Management and energy self-sufficiency**
- **Artificial intelligence**
- **Embedded systems**
- **Robotics**
- **Smart distributed systems**



Hybrid drone (in building)

L@bISEN | AutoROB (Autonomous ROBots)

Pattern recognition
Computer vision
Image analysis
Deep-learning
Remote sensing

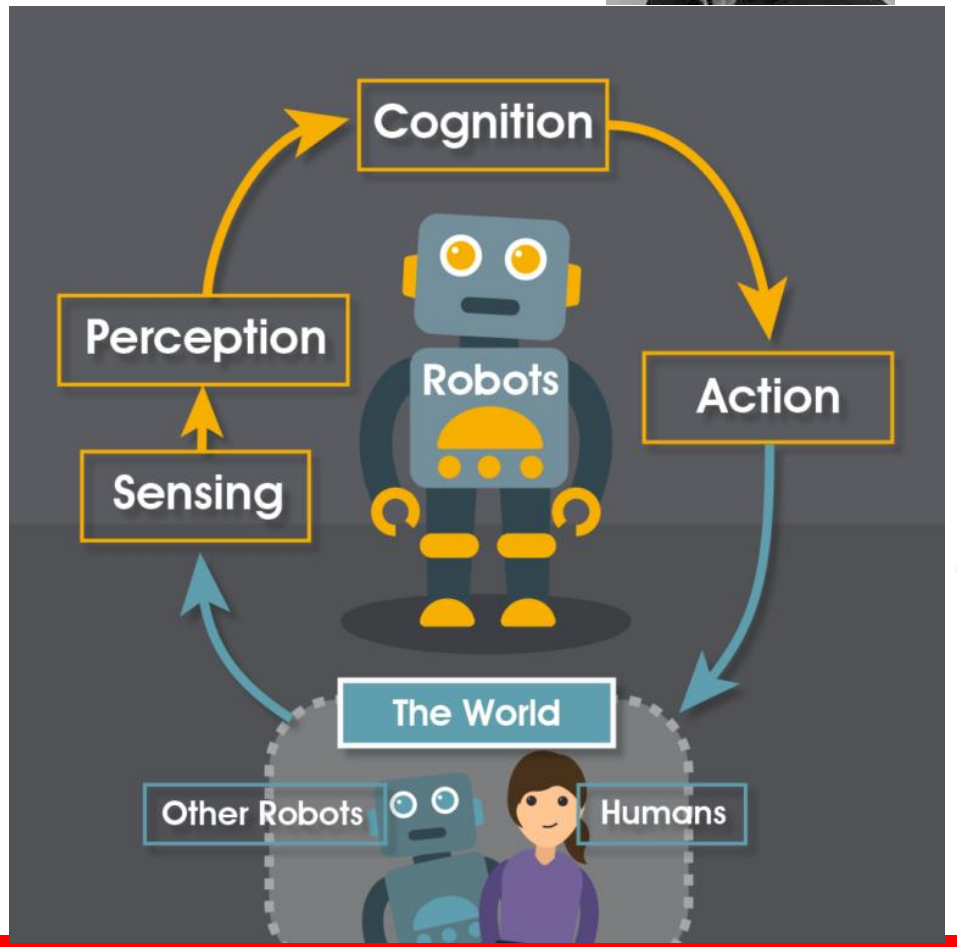
P. J. SOTO VEGA

S. GAMBLIN

Artificial intelligence
Data structures
Modal logic
Probabilistic dynamic epistemic logic
Symbolic model checking
Game theory
Multi-agent systems

Drone and autonomous robot
Embedded system
Distributed architecture
Fleet behavior
Navigation adaptative

T. VERDU



Optimized design
Multidisciplinary Modeling/Simulation
Virtual/Real PrototypingActionneurs
Contactless mechanics
Reconfigurable robots
Soft Robots

H.F. GASPAROTO

TERIAD Project of AutoROB and Vision-DA teams

*"Natural environment preservation using **collaborative drones** and **AI**-based techniques."*

TERIAD Project of AutoROB and Vision-DA teams

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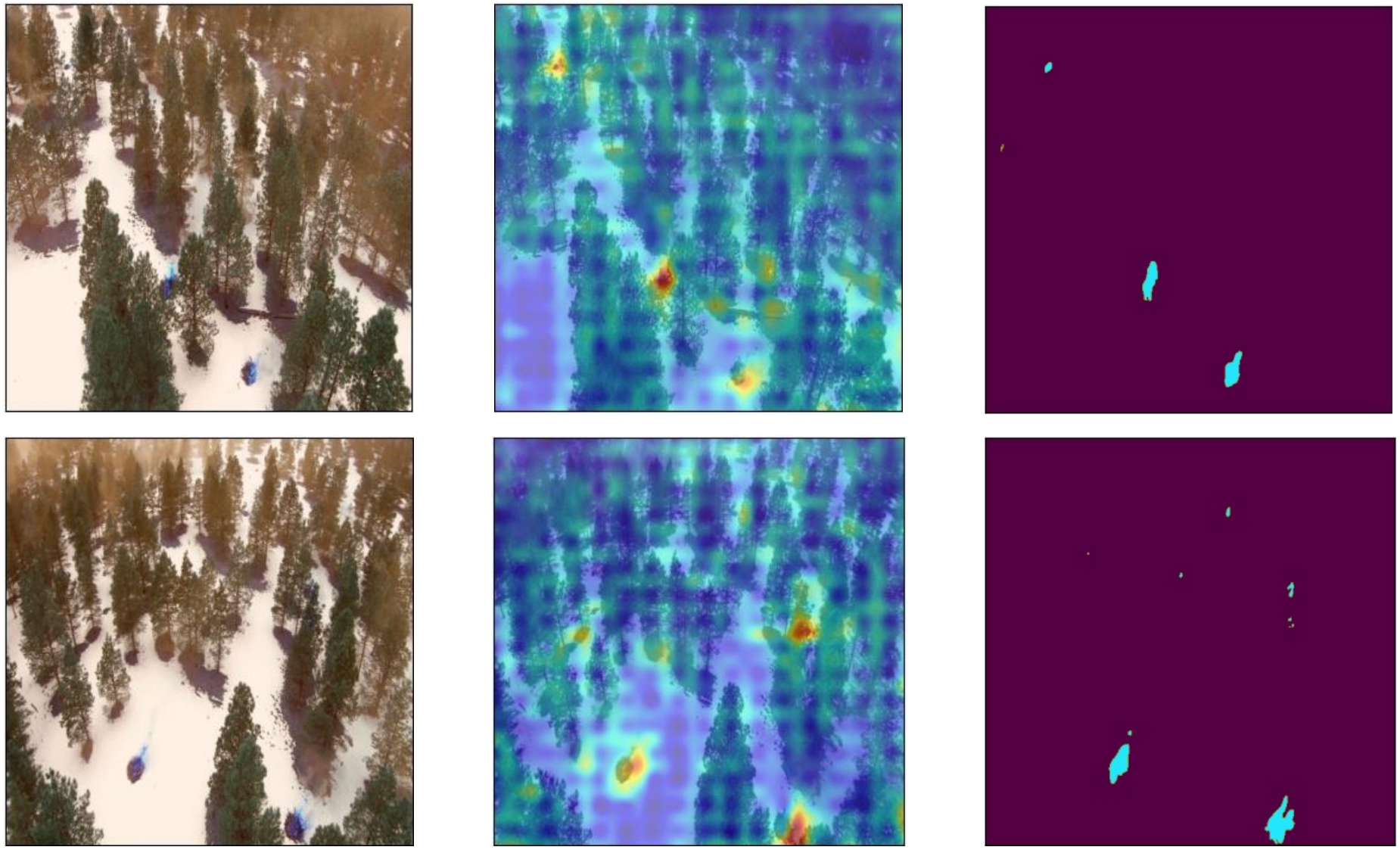
FLAME Dataset

Results with
unsupervised
Machine Learning !



OUTLINE OF THE PRESENTATION

- Context, objectives and administration of the Dronathlon

- AutoROB: development of new aerial drone architectures for missions at sea

L@B ISEN

DRONATHLON

THE DRONATHLON

Call for expressions of interest to identify solutions focused on drones capable of responding to at least one of the two missions selected for this first edition of the "Dronathlon":

- Carry out a reconnaissance of a coastal zone
- Establish the situation in an offshore area outside the EEZ in a logic of control of the air-sea space in a high-end context

- Cohérence avec la stratégie de la Marine et évolutions technologiques
- Réaction à l'organisation de CoHoMa par le Battle Lab Terre
- …

CALENDAR

- End of July 2023: first discussions around ISEN participation
- (Oct. 18, 2023: National Maritime Drone Seminar)
- Nov. 29, 2023: Mission Brief (face-to-face, Toulon)

DRONATHLON

MISSION BRIEF

- 70 expressions of interest, 150 people at the mission brief, 41 pitches
- It will take place in the Mediterranean (off Saint Mandrier in all probability) from 7 to 11 October 2024 (prize-giving planned at Euronaval)
- One week to spend 10 two-hour stickers (possibility of catch-up for the unlucky weather)
- Each GME selected is given a slot, he does not spend the week there
- Applications for January 12; Exchanges with MN from 31 January
- The inspirations are REPMUS and TF 59
- This year's theme is to accelerate multi-environment
- Game rules to be eligible: route position, speed of mobiles in real time in Delta Suite (for safety reasons), at least two drones acting in two environments
- Lots of relevant questions from the audience, lots around Delta Suite

CALENDAR

- End of July 2023: first discussions around ISEN participation
- (Oct. 18, 2023: National Maritime Drone Seminar)
- Nov. 29, 2023: Mission Brief (face-to-face, Toulon)
- 12 Jan 2024: submission of applications

CALENDRAR

- End of July 2023: first discussions around ISEN participation
- (Oct. 18, 2023: National Maritime Drone Seminar)
- Nov. 29, 2023: Mission Brief (face-to-face, Toulon)
- 12 Jan 2024: submission of applications
- 31 Jan 1 Feb. : presentation of the GME in Toulon
- 18 March: pre-consultations, formalisation of groups, NDA, administrative files
- 12 April response to the pre-consultation (quotes financed 40k€ max)
- 13 June 2024: effective award of contracts!
- — Development —
  - Insurance?
  - ISEN is now a drone operator
  - SORA, DREP, ANFR…

LEGAL ASPECT TO FLY A UAV

Carrying out drone flights within the legal framework in compliance with European regulations:

- Declaration of ISEN as a drone operator to the DGAC
- Registration of prototype drones
- Definition of the framework of the mission to be carried out (flight scenario)
- Drafting of a SORA (Specific Operation Risk Assessment) document for sending to the DGAC
- Risk analysis for the DGA (operation on ZICAD)
- Declaration of radio frequencies used for ANFR
- Subscription to civil liability insurance for the remote pilot and drones

LOGISTIC

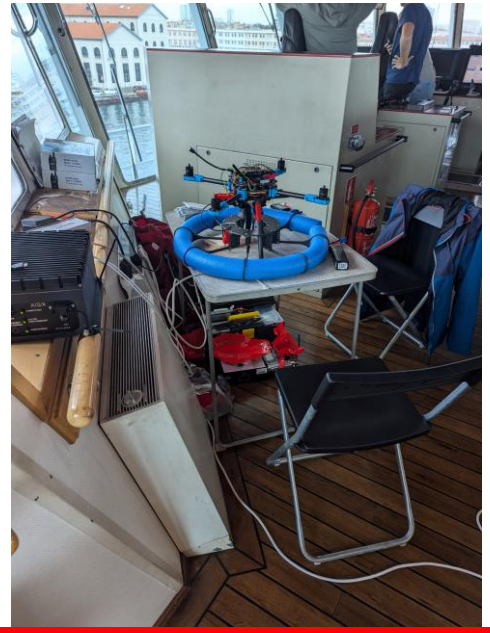
Transporting drones and LIPOs is always challenging: fragile and dangerous equipment

Moving to the other side of France therefore requires transport crates:

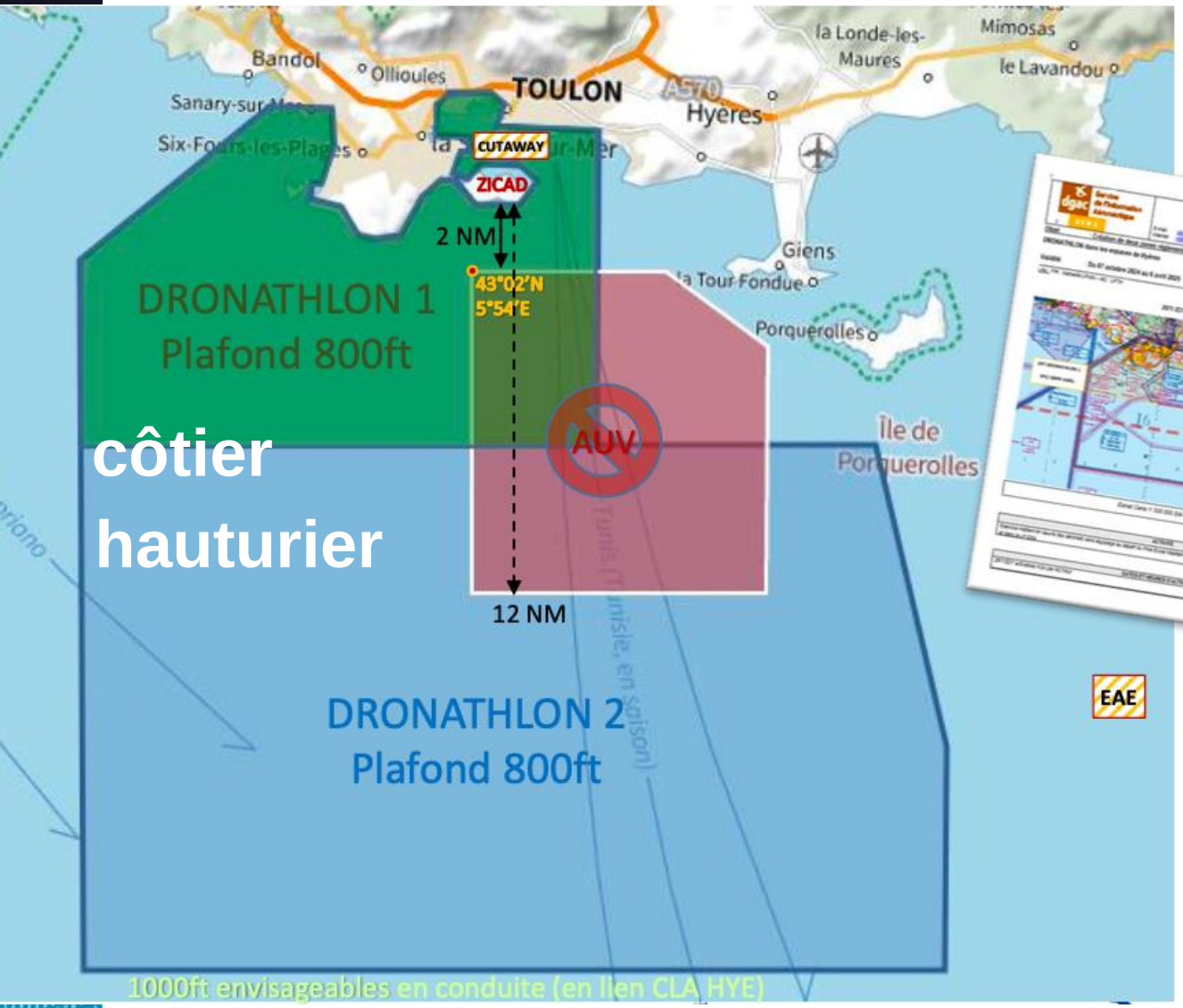
- Very expensive waterproof cases solution
- DIY option (carrying cases filled with foams)

Upstream thinking about the hardware needed to plan a smooth deployment :

- Toolbox for field repair
- Mission simulation to anticipate problems



THE DIFFERENTS MISSIONS

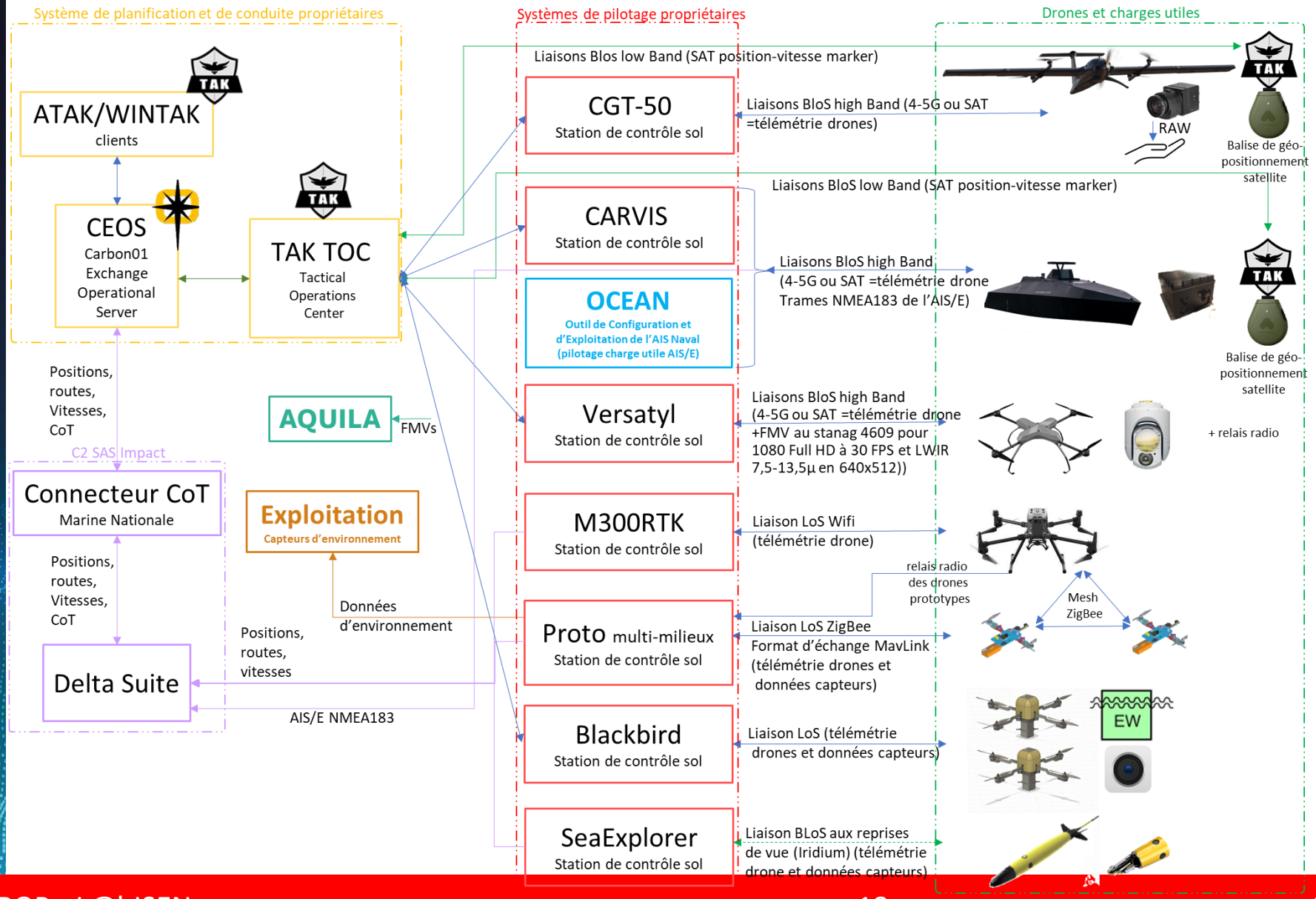


MOYENS envisagés

Soutien GME :
- SeaOwl PIONNIER en S41
- ~~BSAM en S42 (spare)~~
- Semi-rigide d'accompagnement (BSAA P1, SMP P2, DGA-TN P3)

Plastrons :
- FREMM Languedoc
- ~~ESNA ?~~ ~~Confirmé pas d'Améthyste (20/06)~~
- GDM (TBD)
- FLOPHIB (TBD)
- CEPN (moyens passifs)
- NG (TBC) : DDO et STERENN DU

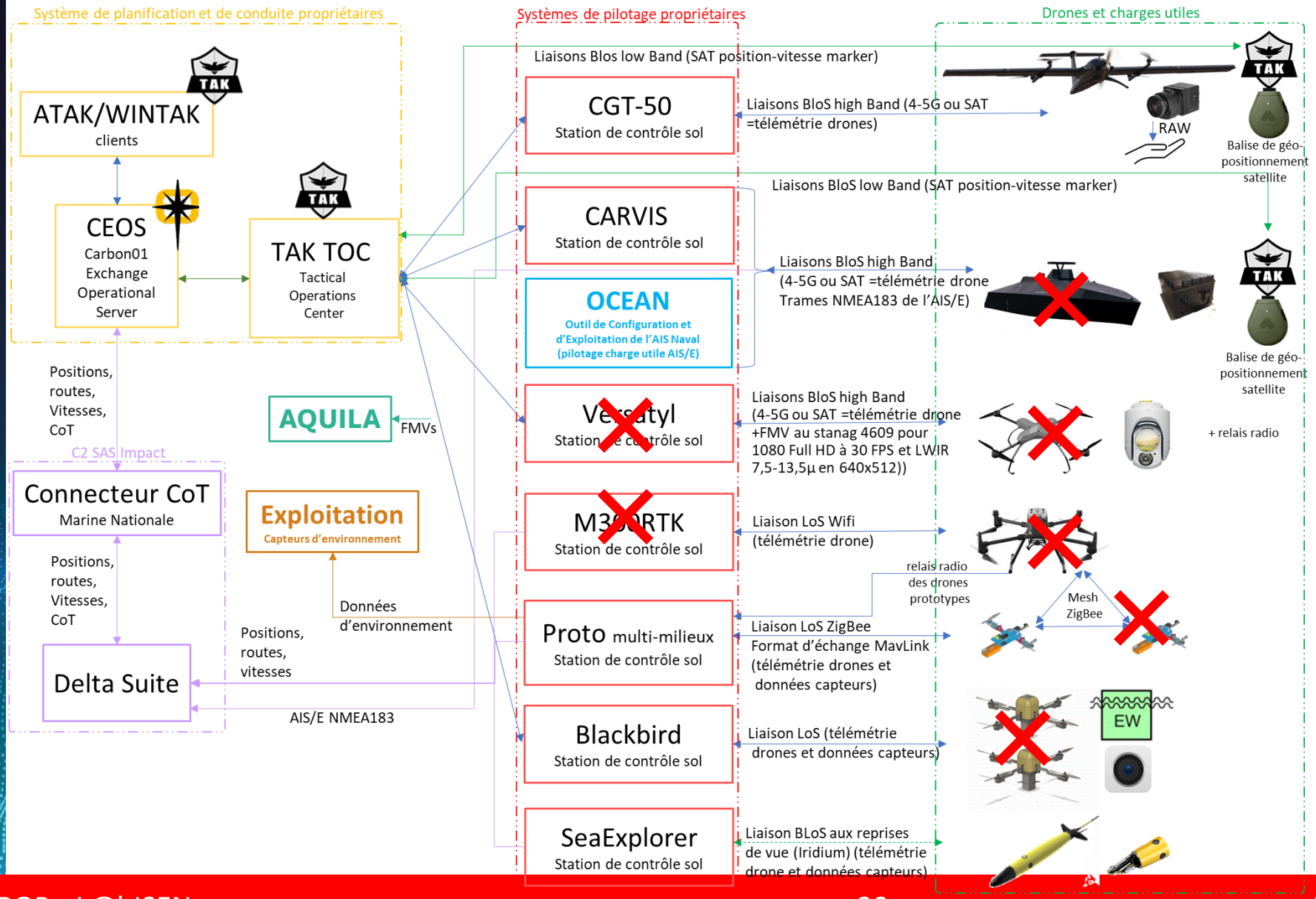
RENSCOT — COTIER



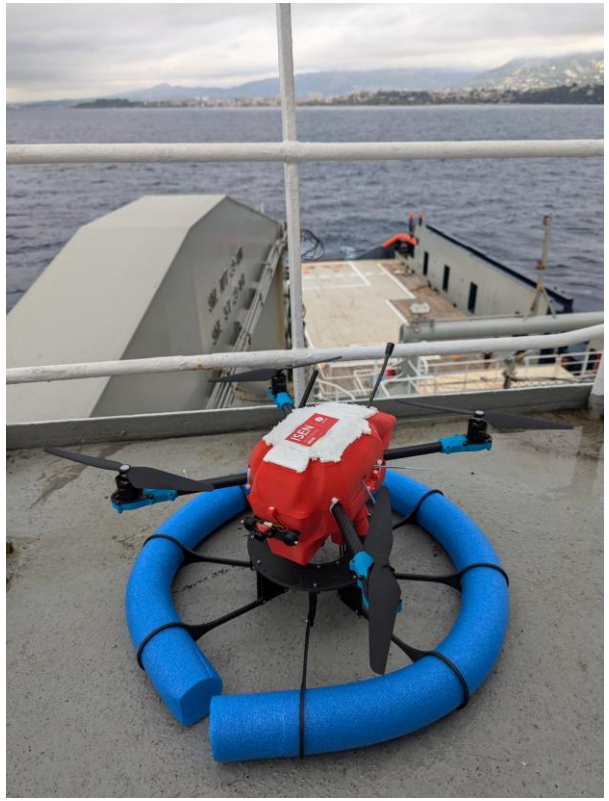
EVENT

- Planified on Monday
- Full day on the Pioneer
- Wind conditions above the state limit on Monday: day for nothing
- Deployment realised on Tuesdays
- The Pelikwad successfully took off from the Pioneer despite a strong wind and landed on the water
- The Pelikwad was taken out of the water by the DGA, returned to the water, and then recovered after about 40 minutes

RENSCOT — COTIER



AUTOROB : Development of new aerial drone architectures for missions at sea



LE PELIKWAD ET L'EKKOCOPTER

PeliKwad :

- Lightweight drone capable of flying and then landing on water
- Ability to take off again from the water to be validated

EkkoCopter :

- Lightweight drone ideally designed to relay messages in a fleet of drones
- Increased communication capacity

MECHANICAL PROTOTYPING OF THE PELIKWAD: SPECIFICATIONS

L@B ISEN

•Experimental laboratory drone for validation of research hypotheses and verification of requested functionalities.

•Drone for the accomplishment of the mission agreed with the contractor (amerissable), with TRL 6 (!).

• Minimum IP 44.

• Ensure orders, design, manufacture, assembly and validation in one month.

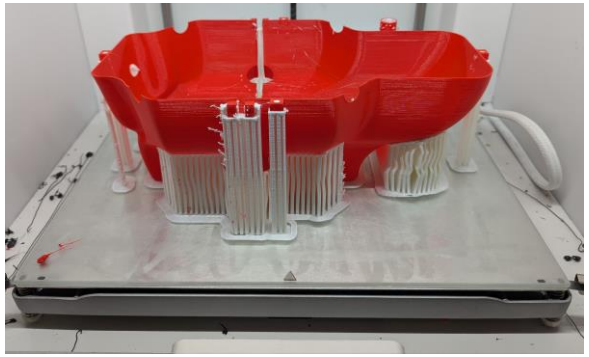
• Spend the minimum amount of money on the prototype due to a significant risk of losing the material.

PELIKWAD MECHANICAL PROTOTYPING: STRATEGY

- Starting from a deliverable:
PX4 Kit – X500v2

- Payload = landing system + salinity sensor + microcontroller + camera (*)

- Use as many resources as possible already available in the laboratory: software, mechatronics workshop with 3D Print, etc.



- Shopping on Amazon

MECHANICAL PROTOTYPING OF THE PELIKWAD: THE PRINCIPLE

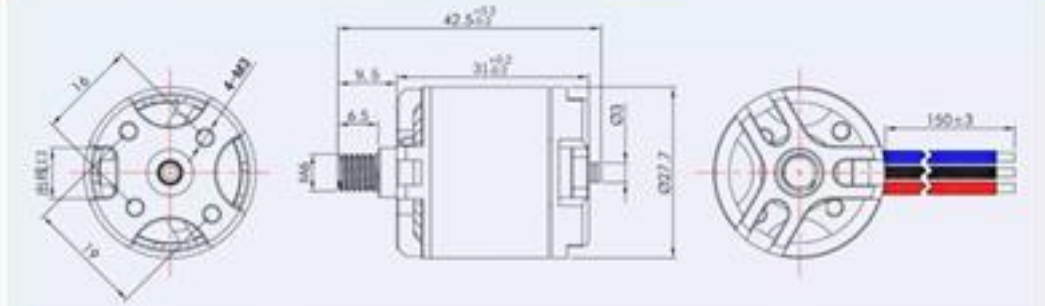
IP ??

DIODON
DRONE TECHNOLOGY

MECHANICAL PROTOTYPING OF THE PELIKWAD: CRITERIA

- Max Propulsion

AIR2216II-Product Drawing



T1045II-Specifications

Plastic Propeller	10* *4.5 (260mmx30mm)	working Temp	-10℃ ~40℃
Weight (Single Propeller)	12.5g	Storage Temp	10℃ ~35℃
Material	Nylon+Glass fiber	Storage Humidity	65±20%RH
Surface Treatment	Matte Technology	Optimum RPM	6000-7000RPM/min
Propeller Type	Polymer Propeller	Thrust Limitation	1.2kg

AIR2216II-Test Report

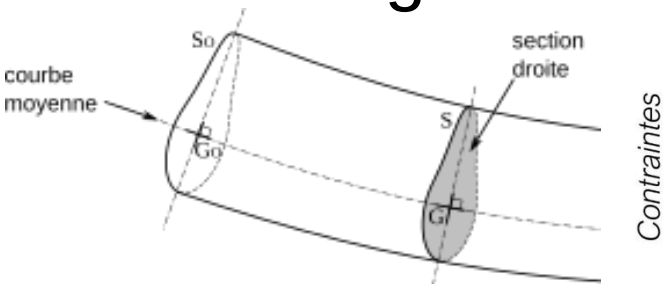
Type	Propeller	Throttle	Voltage (V)	Thrust (g)	Torque (N*m)	Current (A)	RPM	Power (W)	Efficiency (g/W)	Operating Temperature (℃)
AIR2216II-KV920	T1045II	30%	16	210	0.03	1.44	4042	23	9.12	80℃
		35%	16	259	0.04	1.87	4469	30	8.67	
		40%	16	309	0.05	2.29	4855	37	8.45	
		45%	16	373	0.05	2.86	5301	46	8.15	
		50%	16	447	0.06	3.60	5780	58	7.76	
		55%	16	536	0.08	4.53	6298	72	7.39	
		60%	16	628	0.09	5.61	6800	90	7.01	
		65%	16	729	0.10	6.78	7281	108	6.73	
		70%	16	814	0.11	7.92	7679	126	6.44	
		75%	16	906	0.12	9.20	8096	147	6.18	
		80%	16	993	0.14	10.59	8468	169	5.88	
		85%	16	1087	0.15	12.11	8867	193	5.65	
		90%	16	1191	0.16	13.81	9257	219	5.43	
		95%	16	1289	0.18	15.68	9675	249	5.18	
		100%	16	1332	0.18	16.37	9857	260	5.13	

Note: Motor temperature is motor surface temperature @100% throttle running 10mins.
(Date above based on benchtest are for reference only, comparion with that of other motor types is not recommended.)

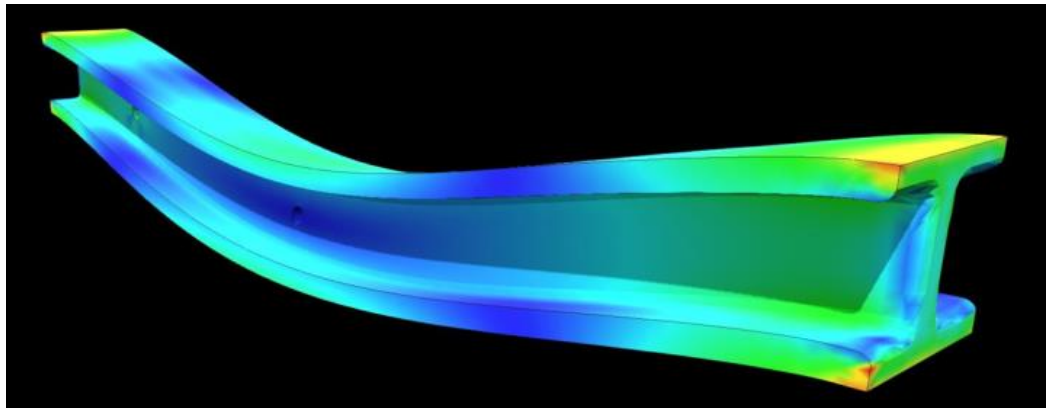
MECHANICAL PROTOTYPING OF THE PELIKWAD: CRITERIA

- Resistance vs Weight

$$\frac{\sigma_{max}}{w} ; \frac{E}{w}$$



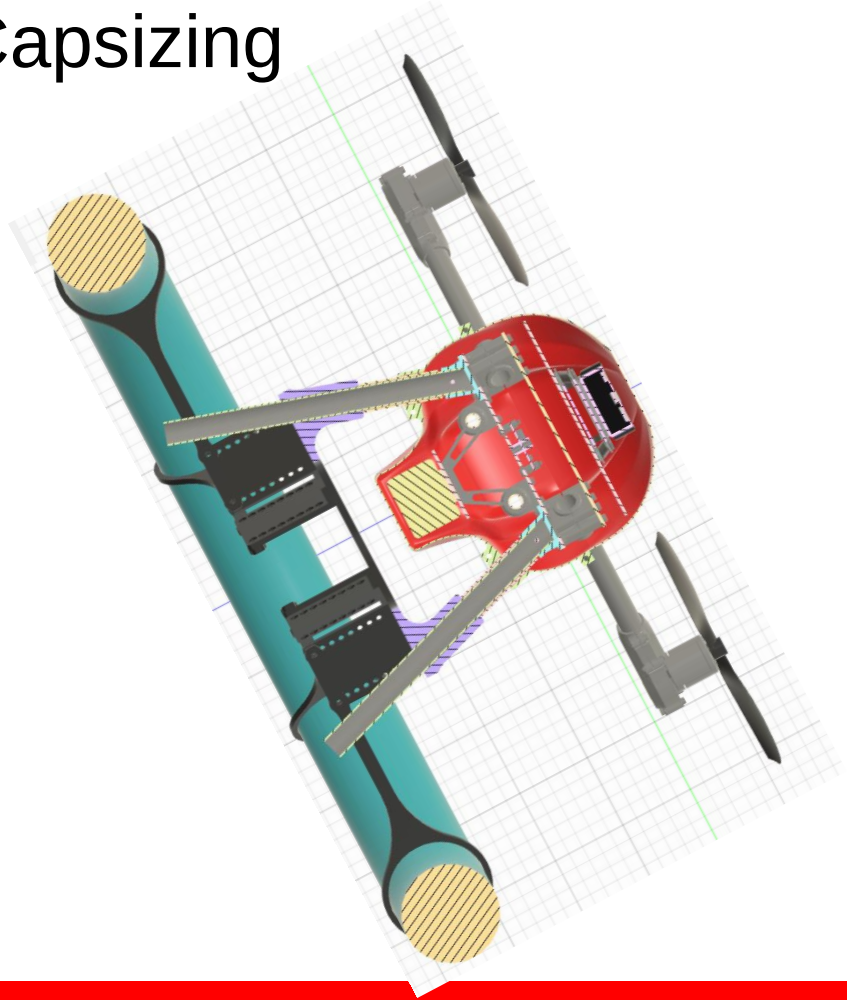
Contraintes

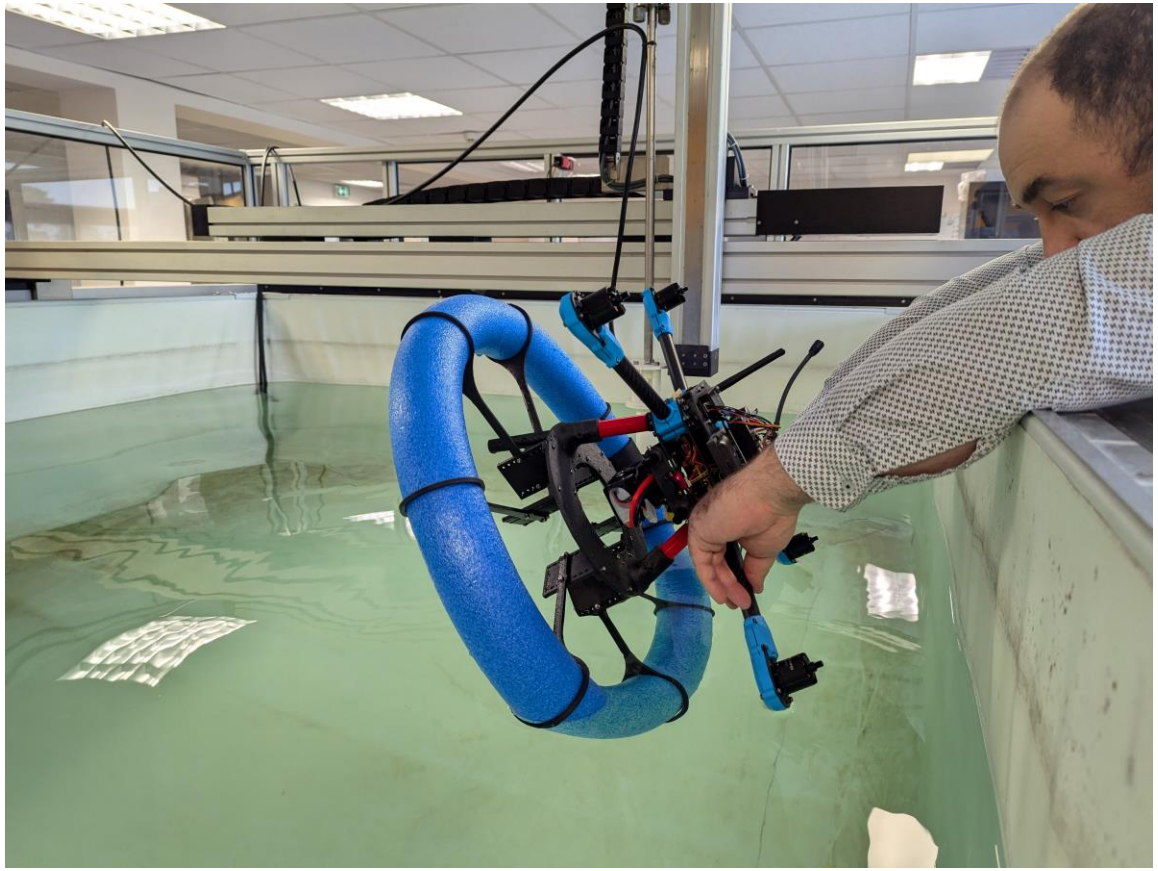


Déformation

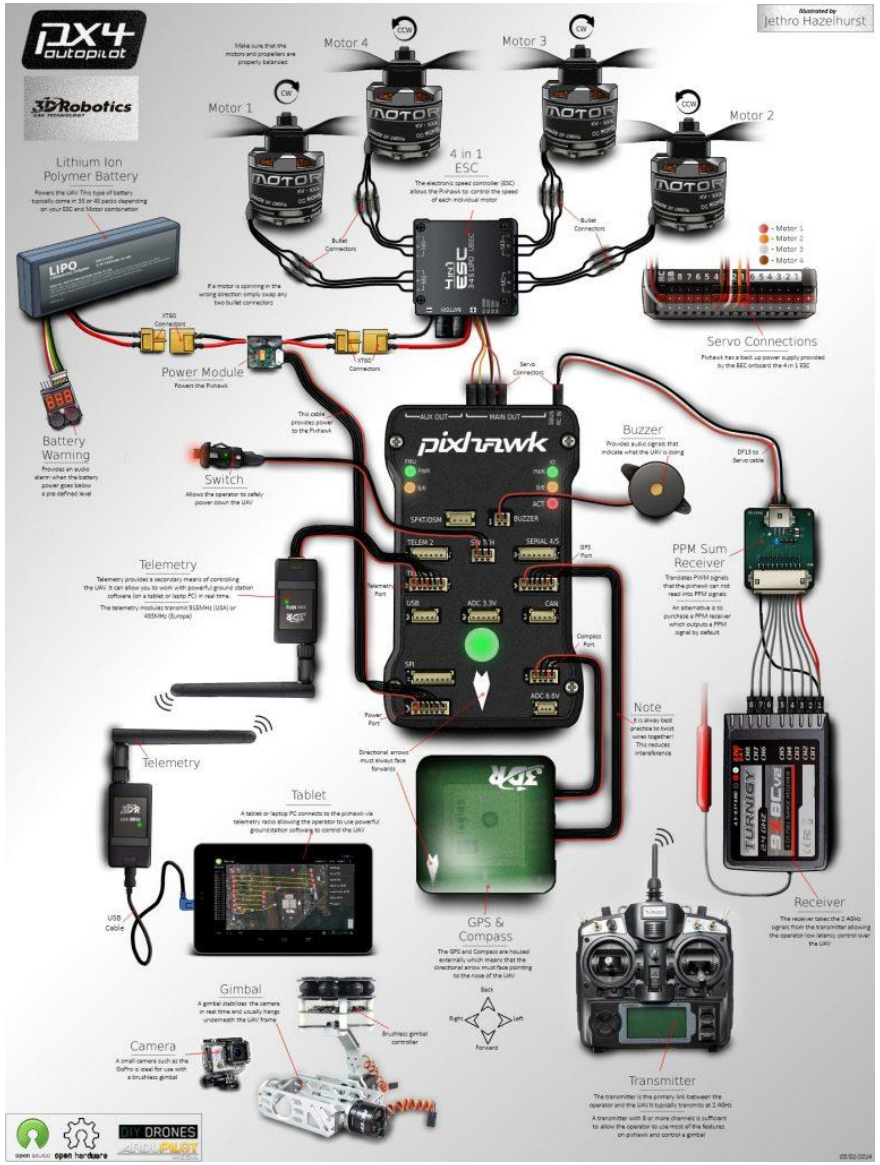
MECHANICAL PROTOTYPING OF THE PELIKWAD: CRITERIA

- Capsizing





ELECTRONIC ARCHITECTURE

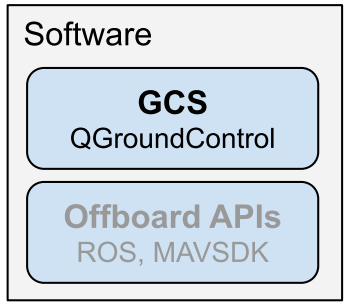


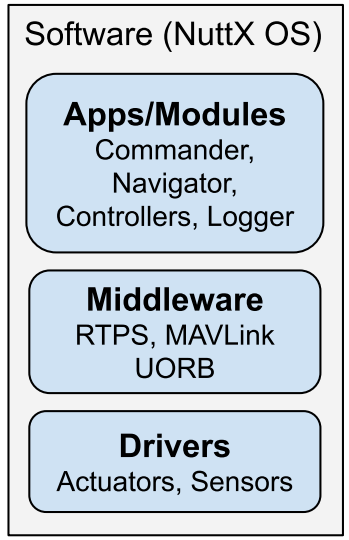
Architecture based on an open-source programmable autopilot board "PixHawk":

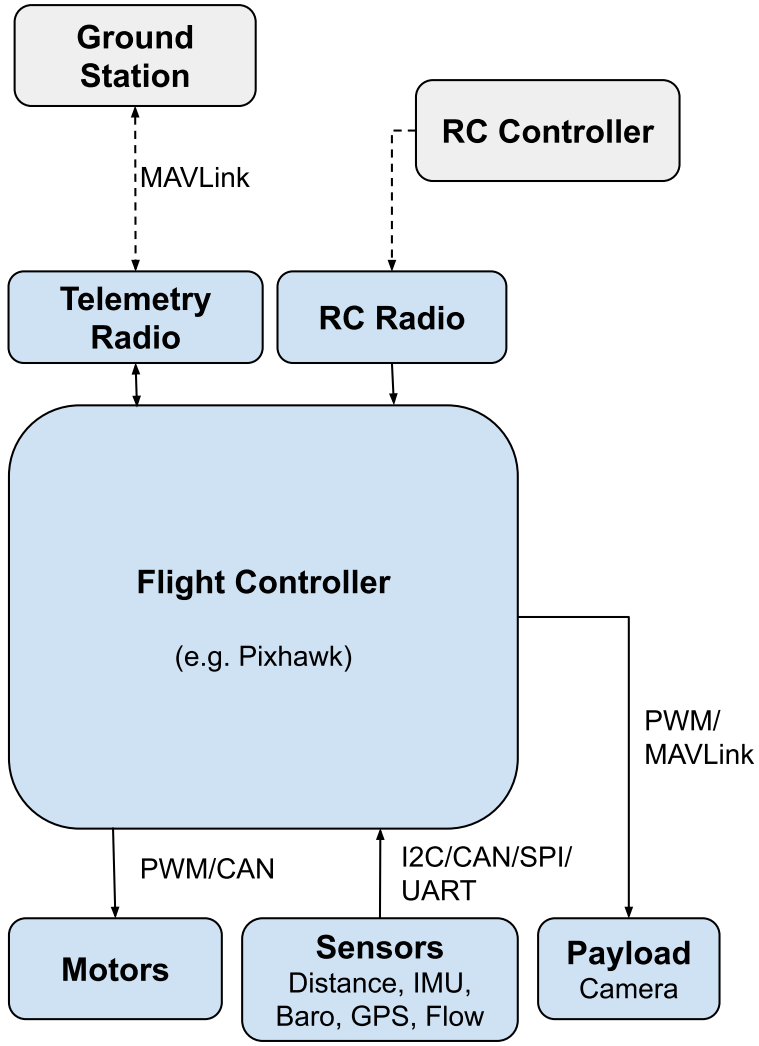
- Microcontroller-based
- Accelerometer
- Magnetometer
- Gyroscope
- Barometer
- GPS
- Numerous inputs for various sensors
- PWM output for motors
- Communication Telemetry and RC

SOFTWARE ARCHITECTURE

- MaVLink main communication protocol
- Ground station chosen according to the desired application (Mission Planner; APM; QGroundControl)
- Connection to a third-party card possible with serial link or MaVLink
- Payload in our case: arduino Nano board with DIY salinity sensor connected via UART

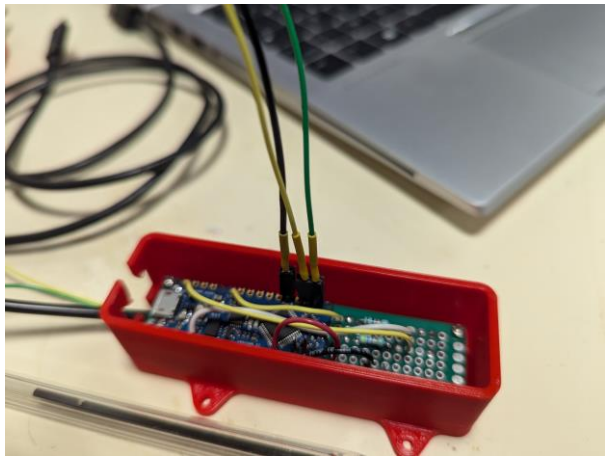


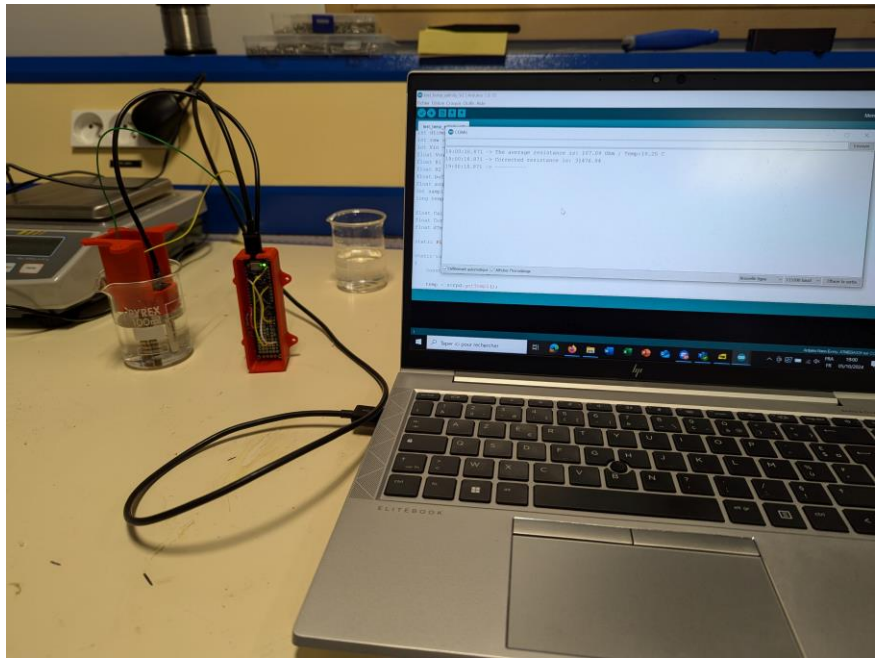




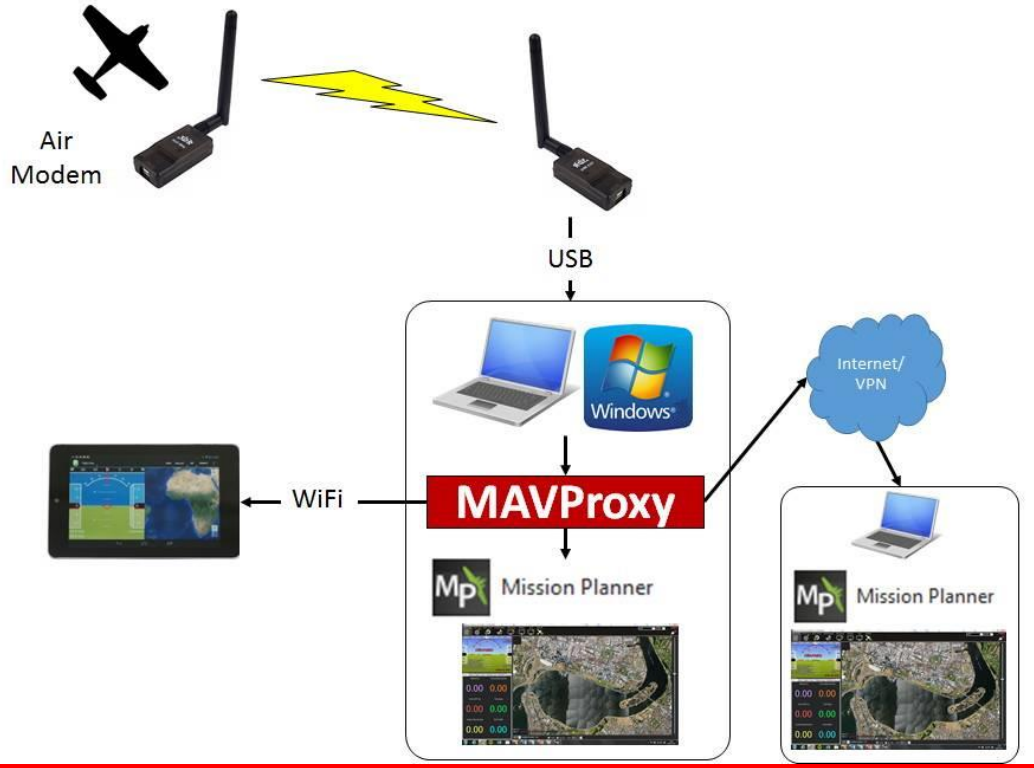
DESIGN PROBLEMS

The conductivity meter or salinity sensor





The interconnection of drones on a single ground station



FIELD DEPLOYMENT

- Flight objectives (manual or autonomous):
  - ✓ PeliKwad take-off
  - ✓ Move 50m away from the mother ship
  - ✓ Splash down
  - ✓ Leave adrift for at least 30 minutes
  - ✓ Take off again
  - ✓ Back on the mother ship

- Very variable weather conditions at sea
- Take-off from a boat not easy (aerology)
- Hull of the boat very disturbing for radio waves

COLLECTED DATA

- PixHawk log files with all the drone's internal sensor data (IMU, GPS, etc.)
- Log files from the Arduino Nano card
- Replay possible on the Ground Station (Mission Planner)
- KMLs can be exported and viewed in 3D on Google Earth

MISSION FEEDBACK

L@B ISEN

MINISTÈRE DES ARMÉES ET DES ANCIENS COMBATTANTS
Liberté
Égalité
Fraternité

DRONATHLON

MARINE NATIONALE

AGENCE INNOVATION DÉFENSE

DGA
DIRECTION GÉNÉRALE DE L'ARMEMENT

MISSION FEEDBACK

THANK YOU FOR YOUR ATTENTION