Thingsat

LoRa communication benchmarks and usecases for near-space balloons and spacecafts

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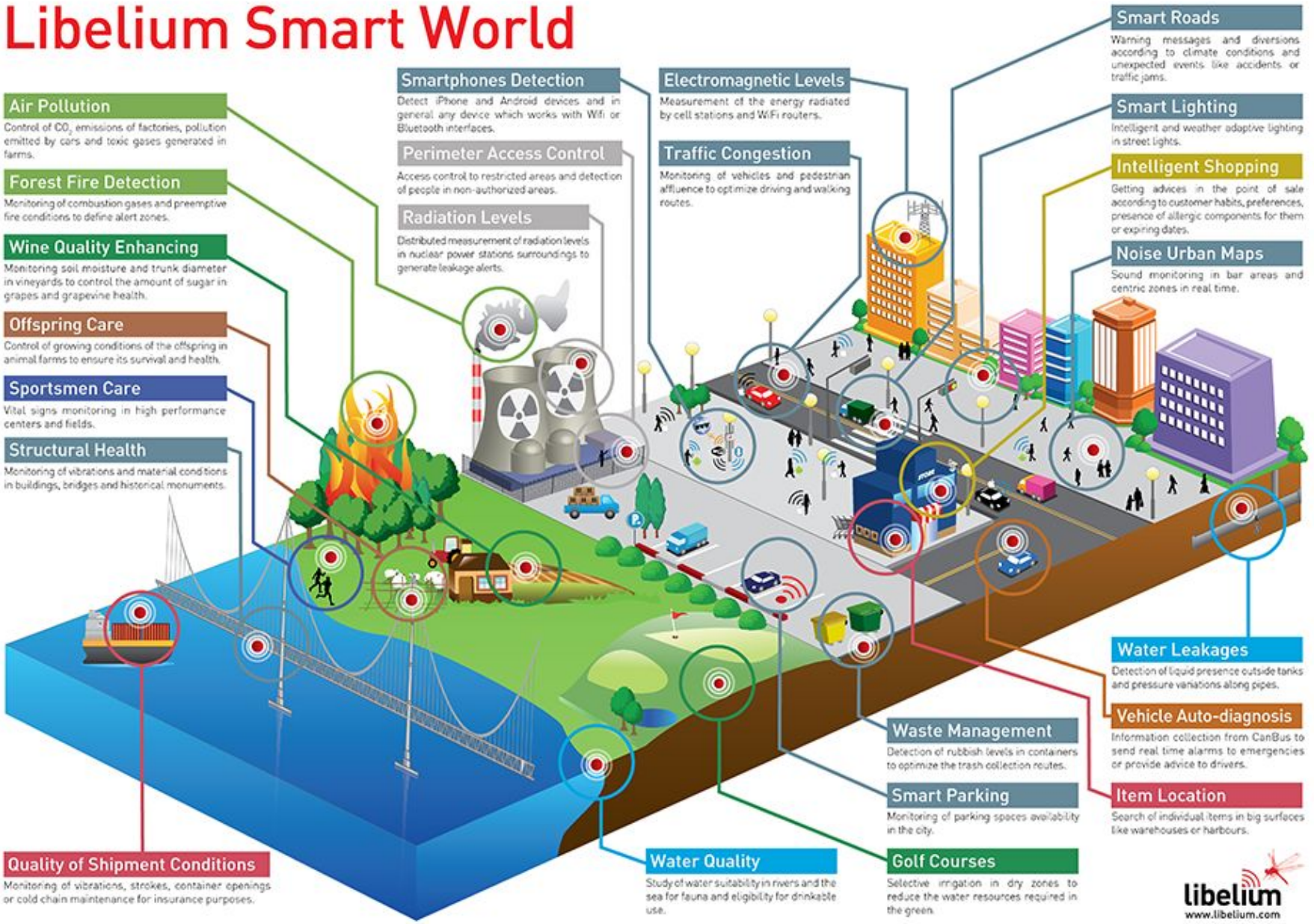
Outline

- Internet of Things and Low Power WAN
- New space and Cubesats
- The ThingSat Project
- LoRa radio perf tests with balloon flights
- Thingsat in the space

The Internet of Things for the Smart World



LoRa & LoRaWAN

- LoRa (Long Range) = Radio modulation
  - Radio modulation patented by Semtech (Spread spectrum).
  - Long Range : 157 dB maximum link budget (up to 20 kms LoS)
  - Low Power (44 mA @ tx 14 dBm)
  - Low Throughput : 290 bps to 5 Kbps (bit not byte)
  - Duty cycle : 1% in Europe for a node
  - Topologies : point-to-point, mesh, star
- LoRaWAN = architecture + encapsulation + ...
  - Open specification (LoRa Alliance)
  - Public and **Private Networks** & Roaming
    - Public networks : Orange, Objectnious (Bouygues Telecom)
    - Private networks : Smart city, Industrial IoT (mine, oil platform …), sovereign nw (mil., airport) , …
    - Roaming hub : Actility

Low-Power and Long Range WAN

Example: Elsys ELT2 (LoRa endpoint with temperature sensor)

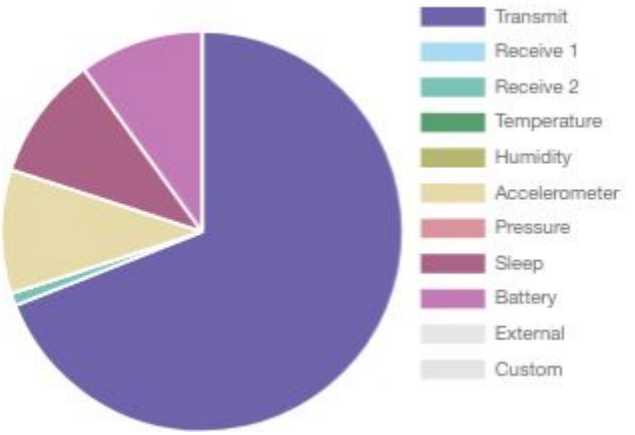
- Battery lifetime from **6** to **18** years (**1 temp. msg/hour**)

Sample time: 3600 Seconds | Sensor: ELT2 HP (Select Elsys sensor) | Battery capacity: 2700 Capacity(mAh) | Battery performance: 80 Performance(%)

Spreading factor: ○ SF7 ○ SF8 ○ SF9 ○ SF10 ○ SF11 ◉ SF12

Result:

The battery will last for **6.2** years*. The sensor will draw **40**uA and **351**mAh in one year.



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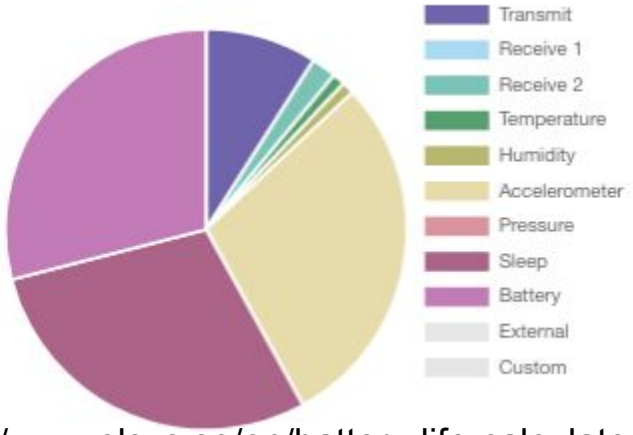
Spreading factor: ◉ SF7 ○ SF8 ○ SF9 ○ SF10 ○ SF11 ○ SF12

Result:

The battery will last for **18** years*. The sensor will draw **14**uA and **120**mAh in one year.



https://www.elsys.se/en/battery-life-calculator/#

Low-Power and **Long Range** WAN

Example: Elsys ELT2 (LoRa endpoint with temperature sensor)

- Mont-Blanc 3835 m alt. → 300 kms → Strasbourg (Eclipse IoT Days 2018)

https://wiki.eclipse.org/images/6/62/Eclipse-IoT-Days-Grenoble-2018-MontBlanc-LoRa.pdf

LoRaWAN public network example
Orange LiveObject (~*8000 outdoor BTS*)

probably SF12 for Orange

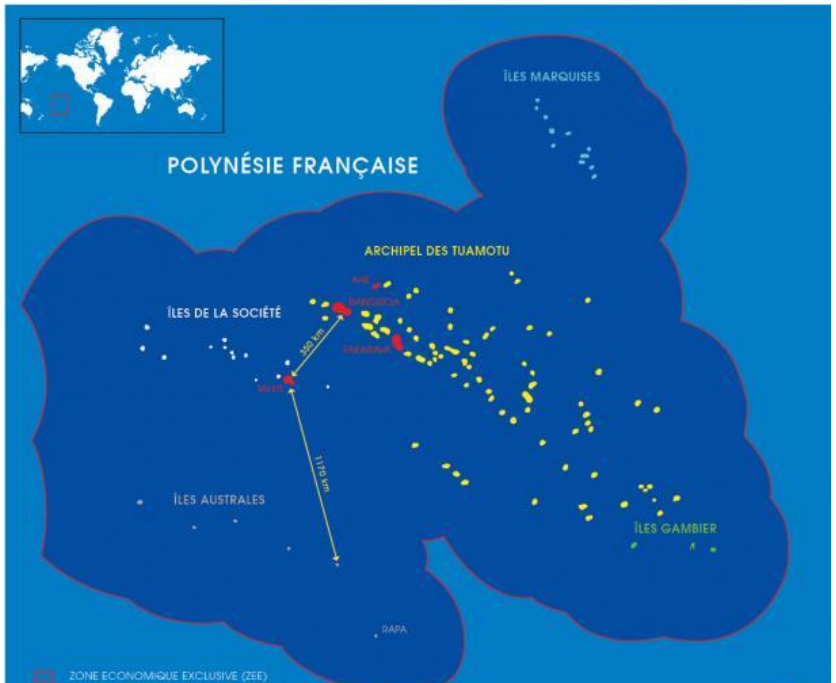
LoRaWAN community network example TheThingNetwork (*~19000 BTS worldwide*)

The Internet of Isolated Things

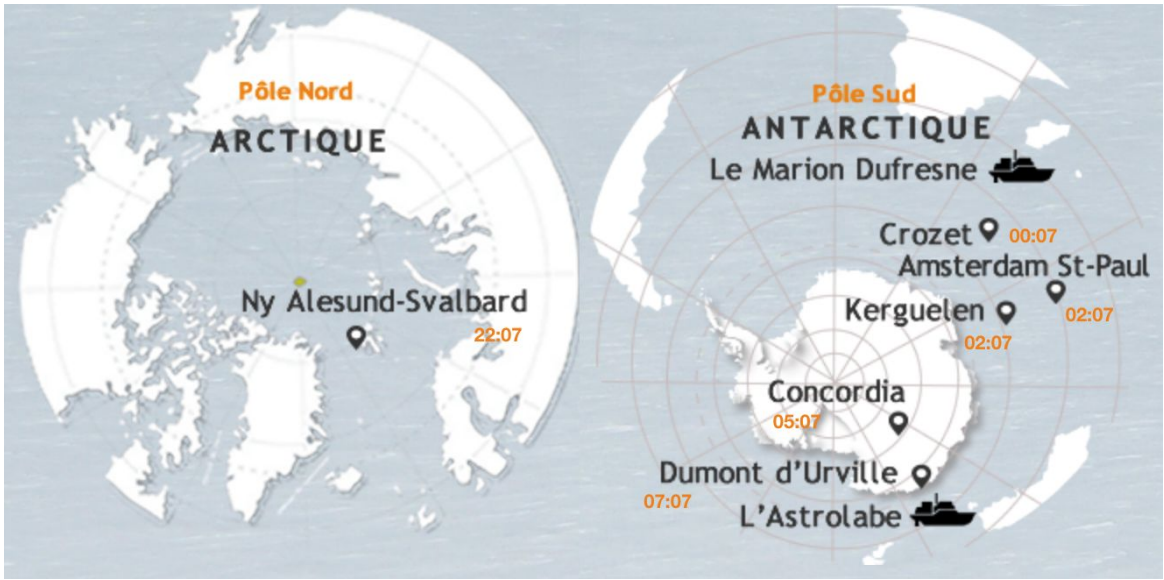
IoT networks cover only a few part of the Earth (*Orbi*)

Deserts, oceans, pole regions, unpopulated areas are “not” connected to the global web

French Polynesia EEZ



IPEV scientific stations

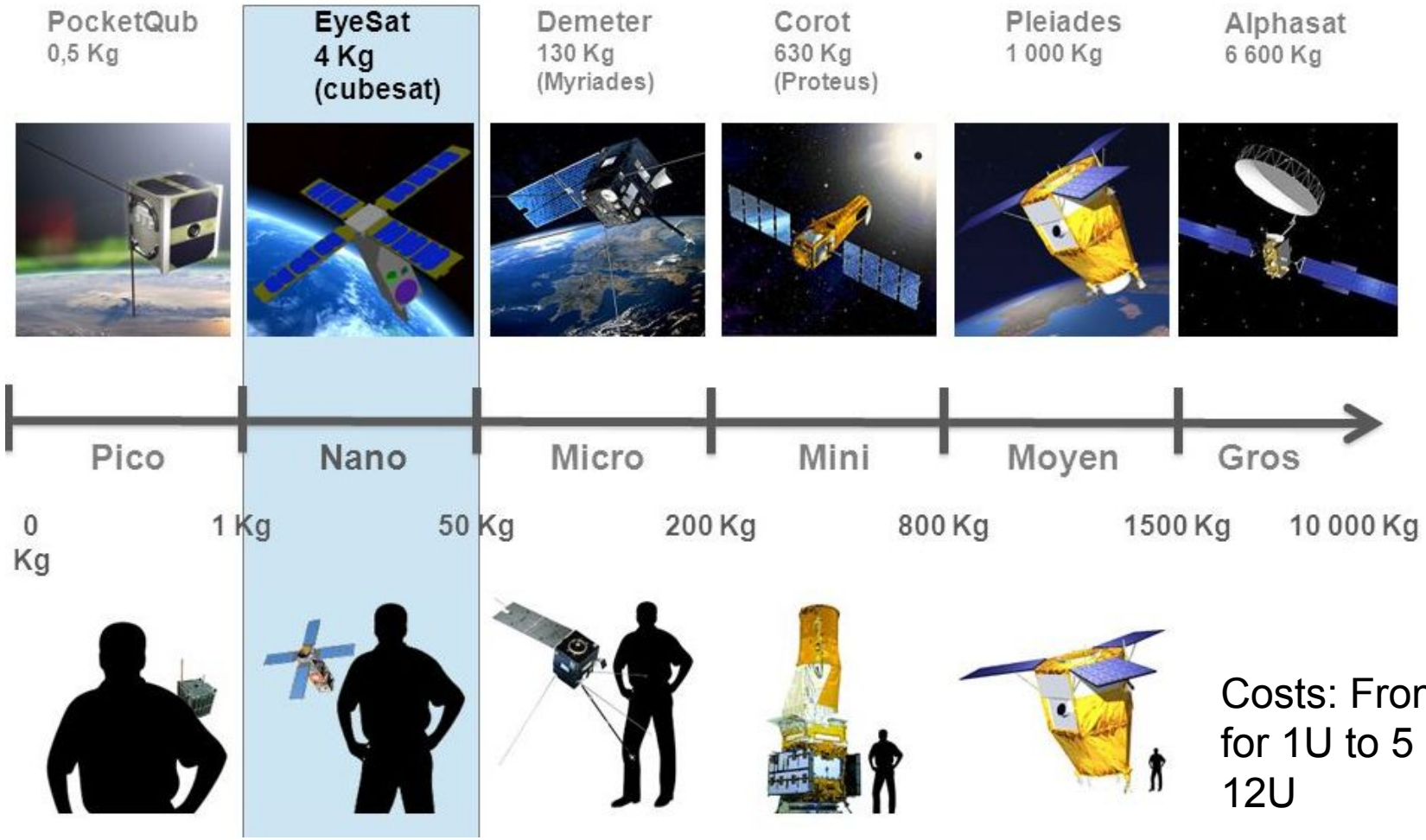


Sat-IoT

- Principle
  - “Fat” satellite constellation relays messages from/to alone ground objects.
- Satellite-IoT
  - Since more than 10 years
  - Messaging services, geo-Location services
  - Terminal drawback : cost, energy, subscription, volume
  - Operators : Iridium, Eutelsat, Orbcomm, Argos, Inmarsat, Rock7, ...

“New space” & Cubesats

- Agile and “affortable” LEO satellites



Costs: From 500 k€ for 1U to 5 M€ for 12U

https://www.cubesatshop.com/
http://www.isispace.nl

Low Power Global Area Networks (LPGAN)

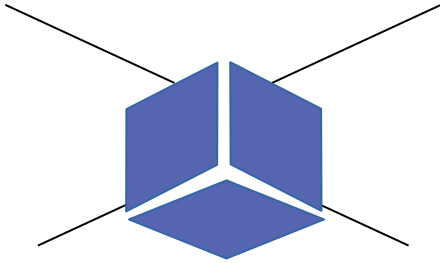
Motivations

- Affordable low power and miniaturized terminals
- “Affordable” cubesats constellations
- Affordable network of ground stations
- **Reuse ground (public, private) networks**

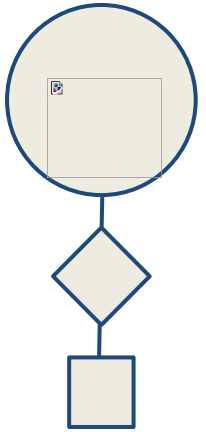
The ThingSat project

Research vehicle for

1) Testing LoRa-based modulation for
- ground station ⟷ cubesat communications
- end-point ⟷ cubesat communications
- cubesat ⟷ cubesat communications

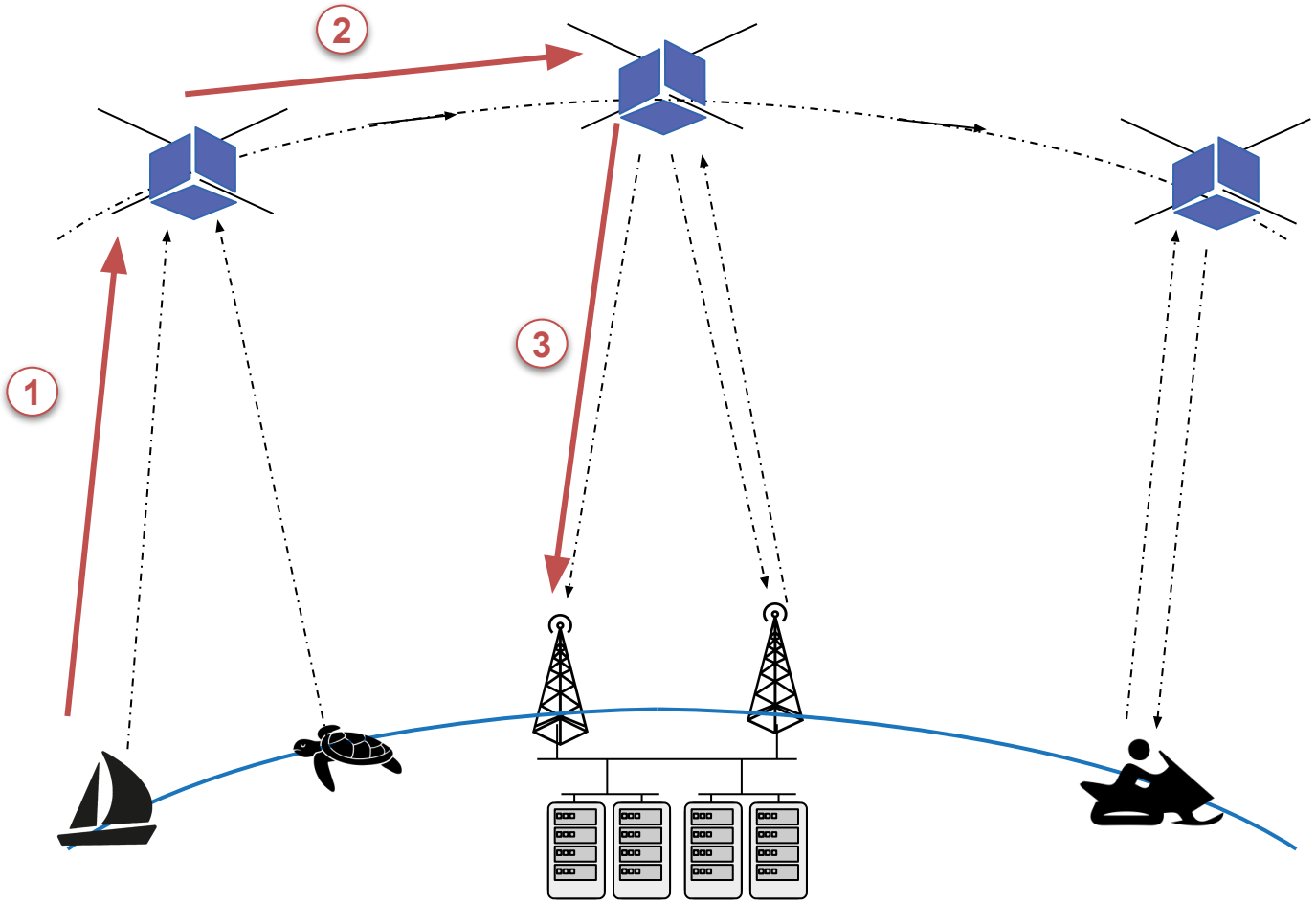


2) Testing applications LPGAN
- delay tolerant networks EP ⟷ CS ⟷ GS
- roaming between ground networks
- multi-lateration of EP
- clock distribution
- track and monitor “zombie” or EoL satellites



Thingsat
Delay Tolerant Network

nano satellite constellation which relays LoRa messages received from end-nodes on the ground



https://www.youtube.com/watch?v=4G2d3ek7PTQ&t=67s

Very long range radio tests
LoRa in the Near Space

Goal

- Benchmarking LoRa™ modulation link margin and distance per LoRa radio parameters (TxPower, SF and BW) on several ISM bands (433 MHz, 868 MHz, 2.4 GHz)

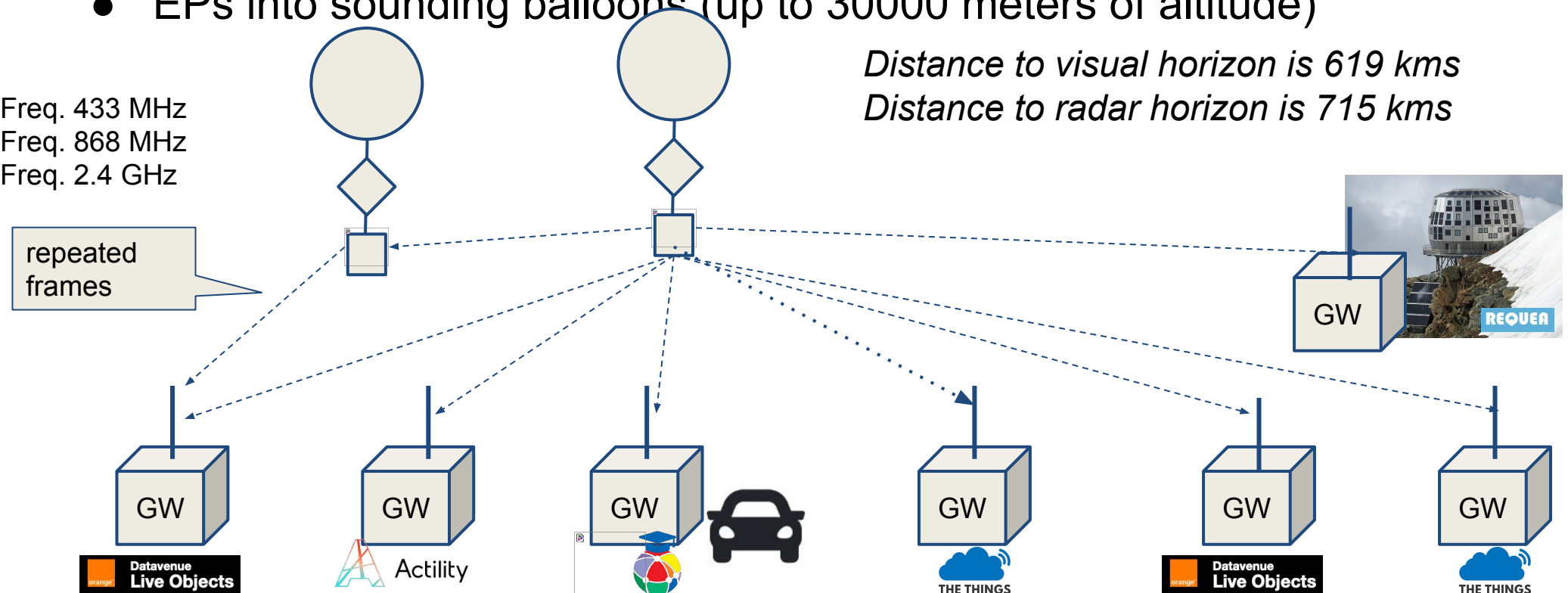
How

- EPs into sounding balloons (up to 30000 meters of altitude)

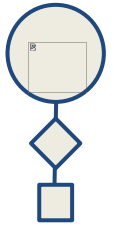
Distance to visual horizon is 619 kms
Distance to radar horizon is 715 kms

Freq. 433 MHz
Freq. 868 MHz
Freq. 2.4 GHz

repeated frames



Very long range radio experiments

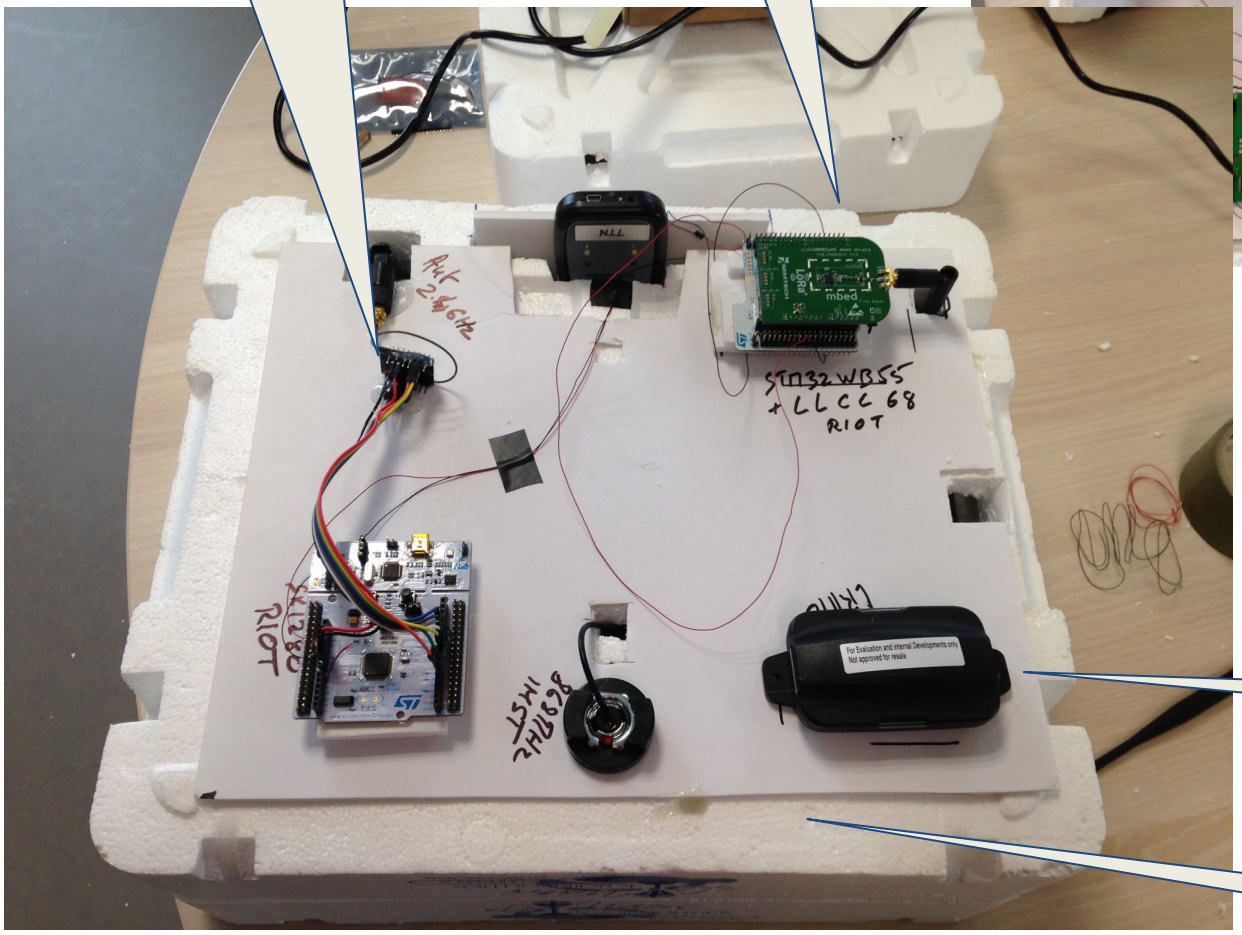


- Expe #1 “L’envol d’Albert” (May 2019)
  - 2 endpoints (868 MHz)
    - CSUG
- Expe #2 CNES (Sept 2020)
  - 12 endpoints (433 MHz, 868 MHz, 2.4 GHz)
    - CNES,CSUG, ANS Innovation, Semtech, Orange
- Expe #3 CNES (April 2021)
  - 24 endpoints (433 MHz, 868 MHz, 2.4 GHz)
    - CNES, CSUG, ANS Innovation, Semtech, Orange, Actility

Expe #3 April 2021

Nucleo + LLCC68 MBed

Nucleo + SX1280 2.4GHz



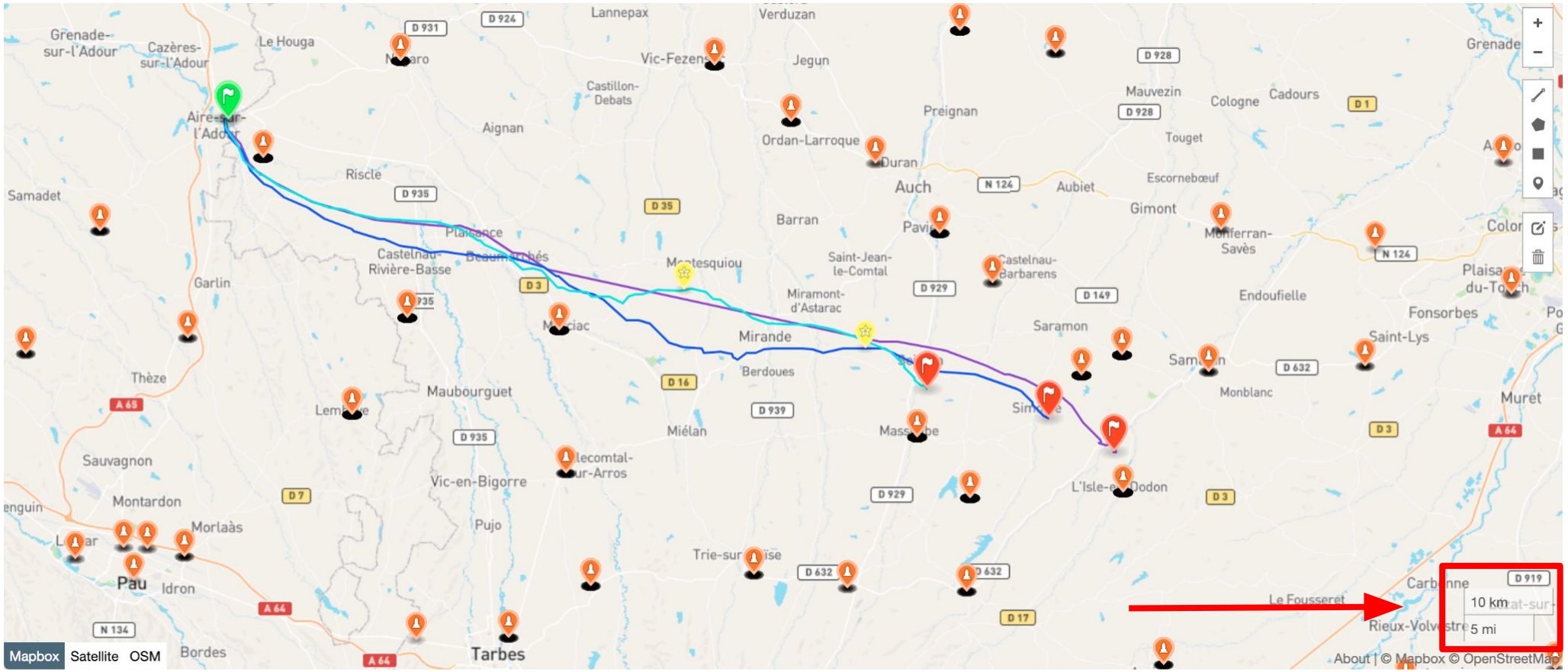
STM32WL55 433MHz

RPI + Corecell SX1302

LR1110 eval kit

recycled polystyrene fish boxes + duck tape

Expe #3 April 2021 (CNES, Aire-sur-l'Adour)

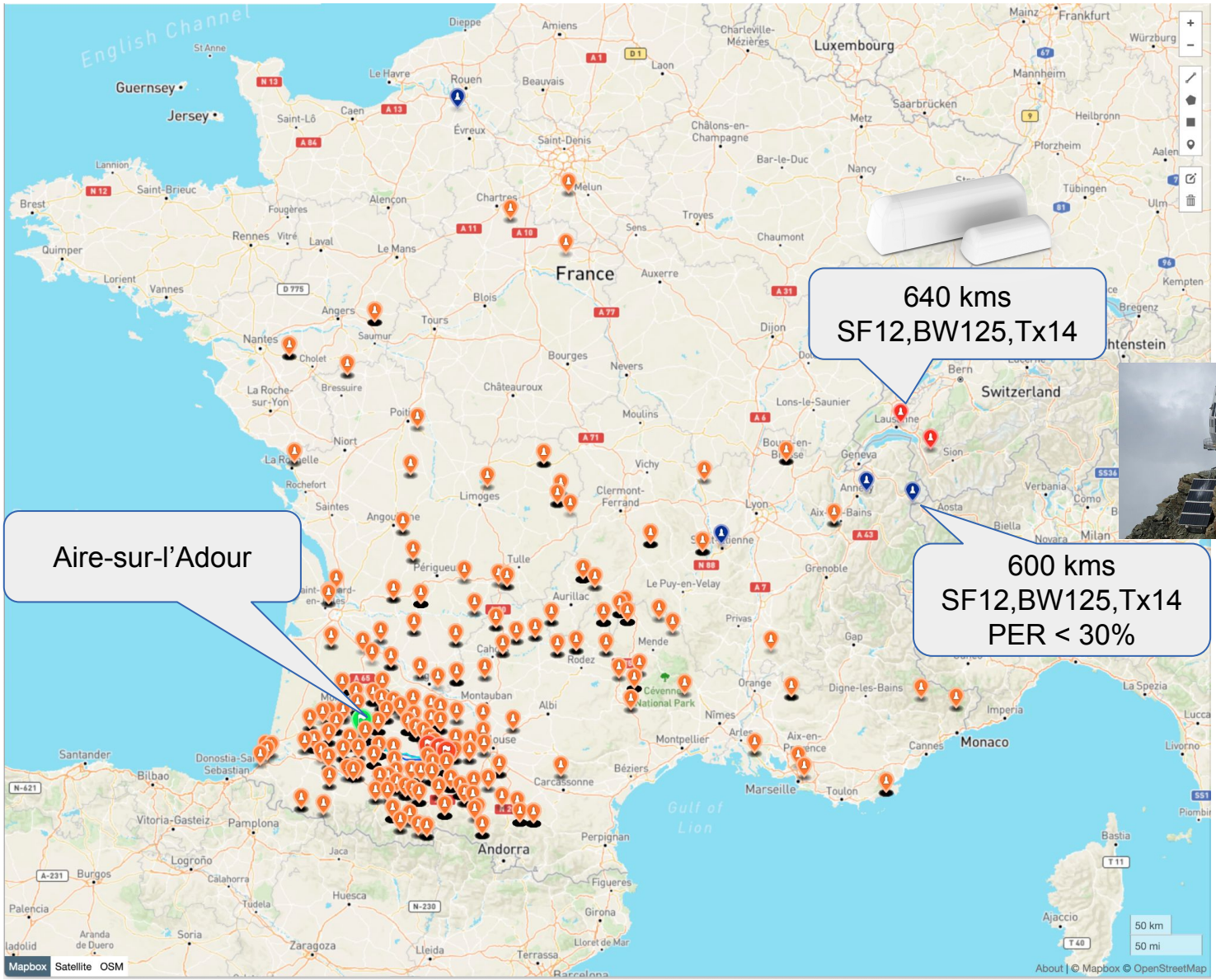


~100km (legend below right)
Balloon #1's track in blue (max altitude : 30913 meters in yellow)
Balloon #2's track in cyan (max altitude : 28349 meters in yellow)
Balloon #3's track in purple (waiting for CNES GPS data)

https://gricad-gitlab.univ-grenoble-alpes.fr/thingsat/public/-/tree/master/balloons

Expe #3 April 2021

Orange gw
Swisscom gw
Requea gw
UGA gw



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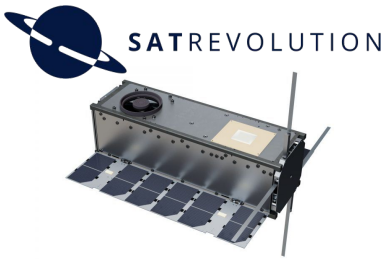
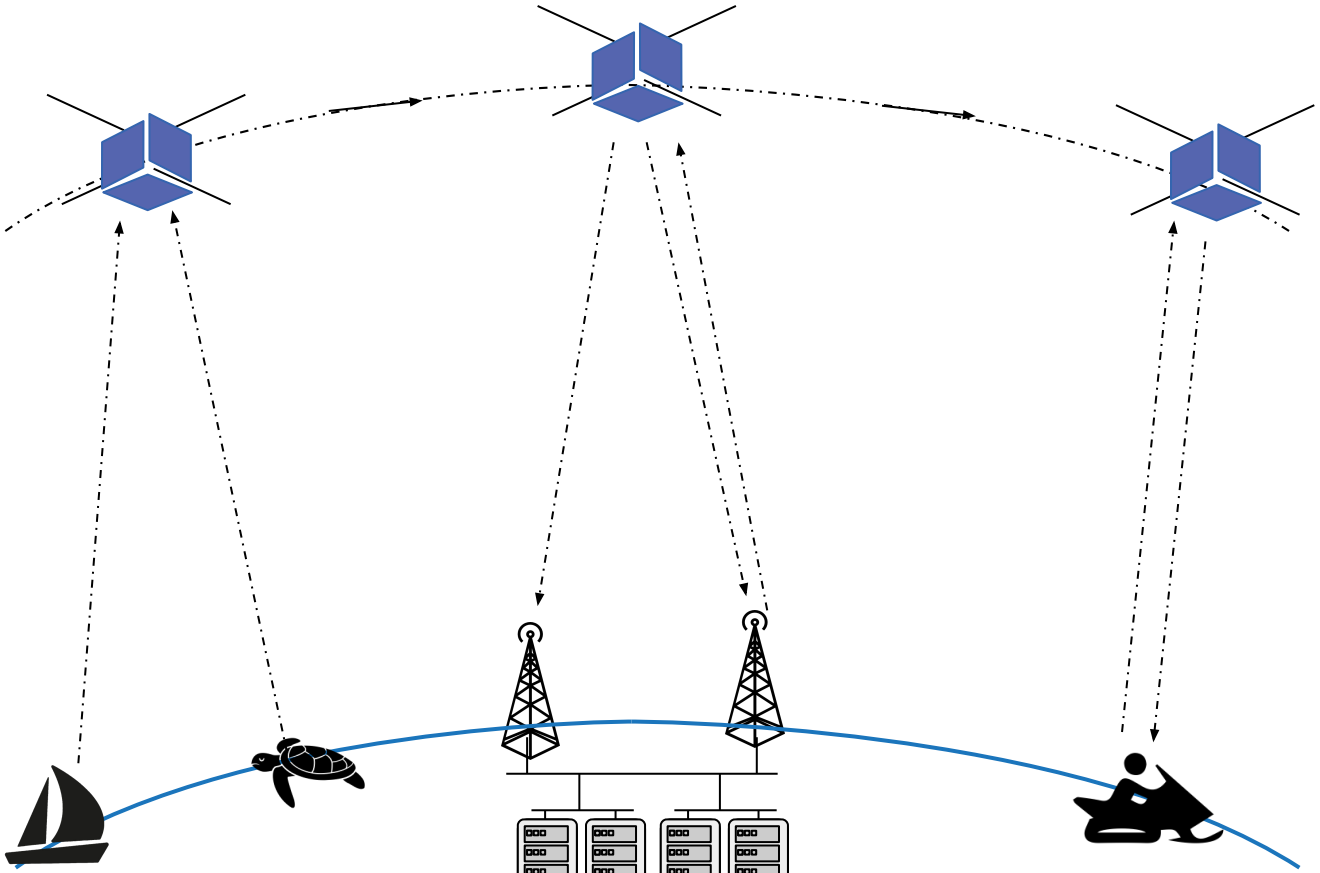
Next LoRaWAN experiments from space (LEO 500 kms alt.) Sept 2021 to April 2022

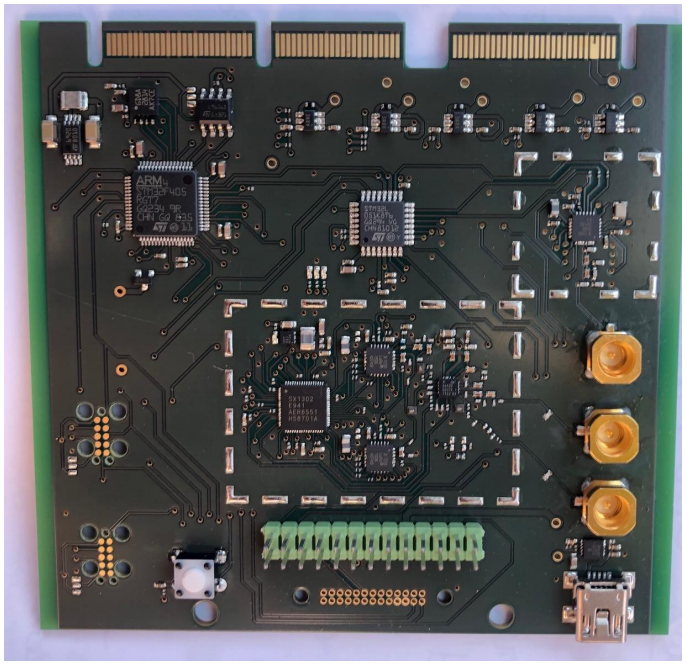




The ThingSat project of CSUG

- **868 and 2G4** LoRa experiment from and towards the cubesat
- heliosynchronous LEO orbit. Launch June 2021 in the commercial mission STORK SatRevolution

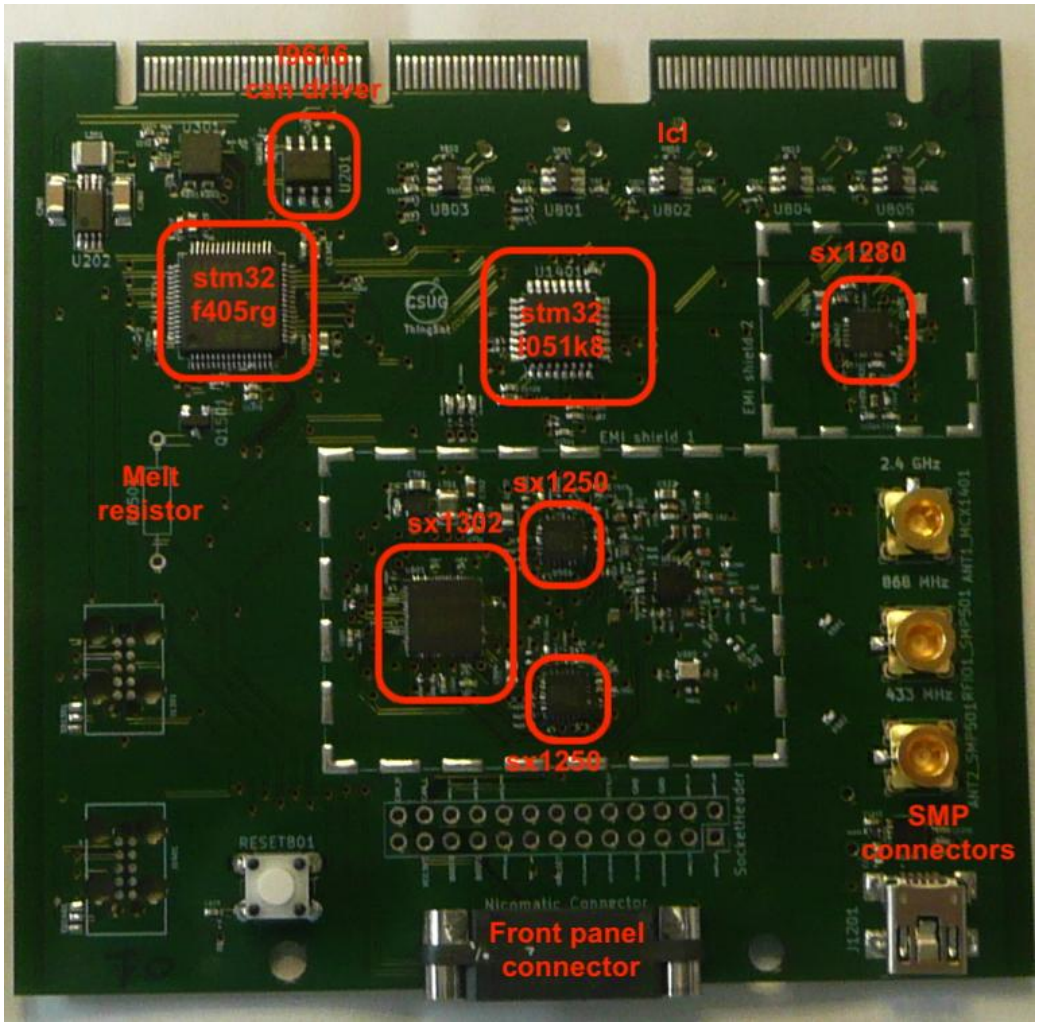
Engineering Model



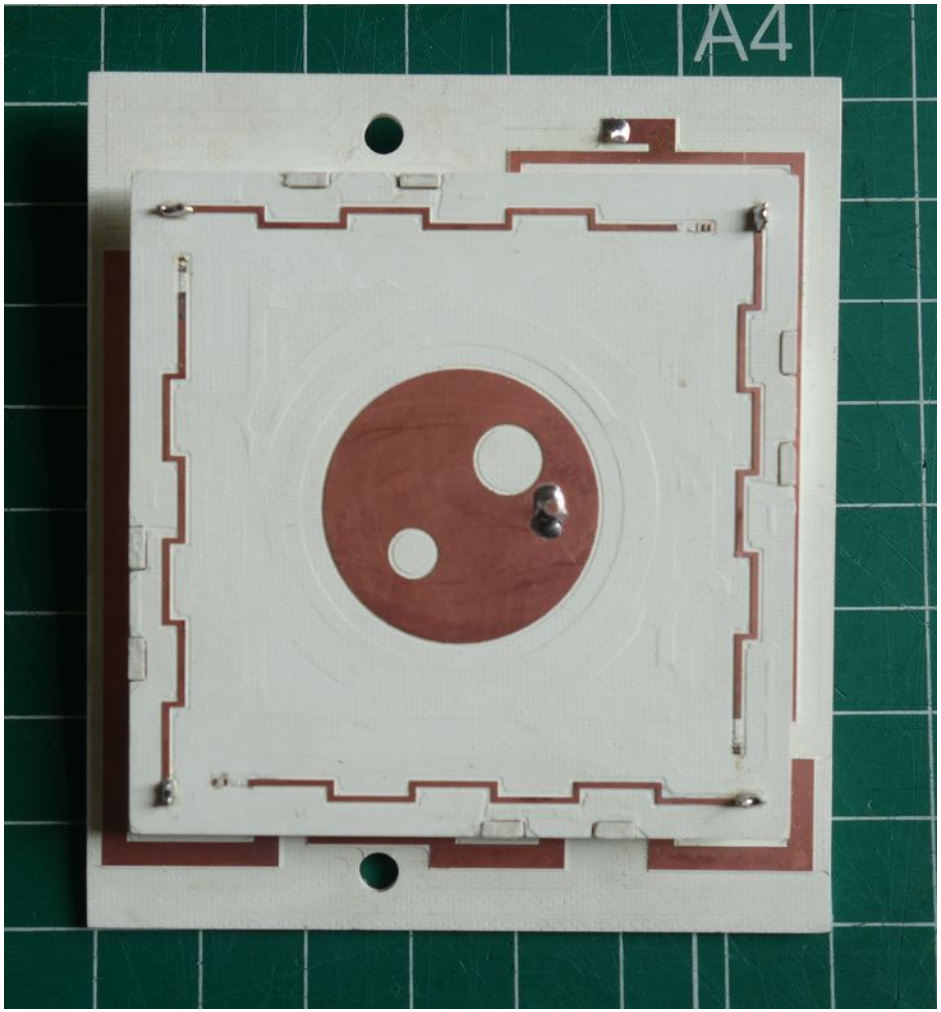
Flight Model

SATREVOLUTION

Details of the Thingsat board and antenna



Flight Model



Dual band antenna

Open to collaboration for testing LoRa in the space

Research teams

Radio Amateurs

TinyGS volunteers community https://tinygs.com/satellite/ThingSat