Cubesats: a low cost opportunity for IoT satellites

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Bernard Tourancheau ...

Journées ResCom
Lyon, 11 & 12 Juillet 2019

CSUG

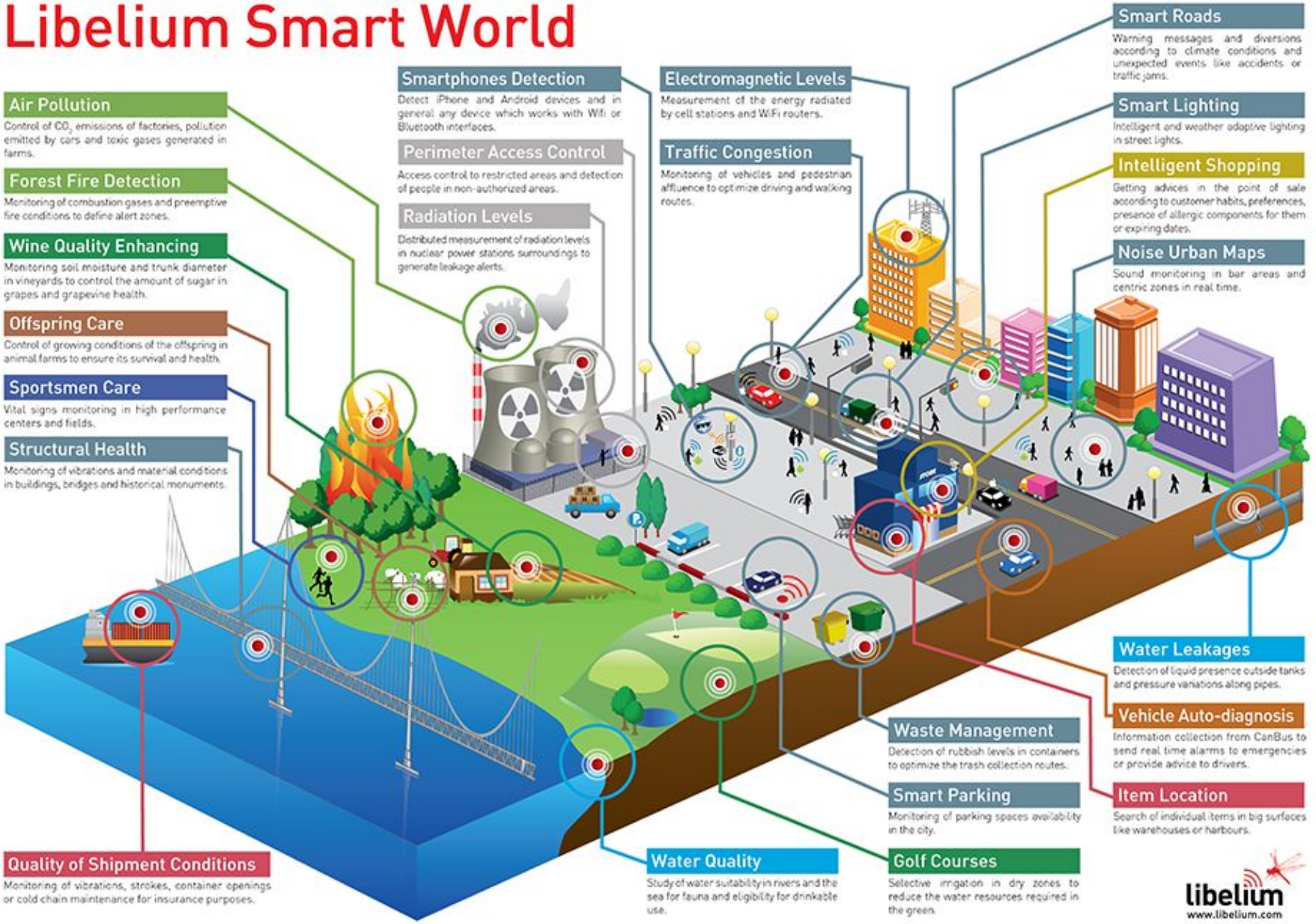
Communauté UNIVERSITÉ Grenoble Alpes

UPF UNIVERSITÉ DE LA POLYNÉSIE FRANÇAISE

Outline

- Internet of Isolated Things
- Sat-IoT and Low-Power Global Area Neworks
- CSUG
- The ThingSat Project
- Field tests
- LoRa radio perf tests with balloon flights

The Internet of Things for the Smart World



Low-Power and Long Range WAN

- LoRa/LoRaWAN
- Sigfox
- NB-IoT and LTE-M (3GPP)

covers most of the (previous) IoT use cases

Low-Power and Long Range WAN

Example: Elsys ELT2 (LoRa endpoint with temperature sensor)

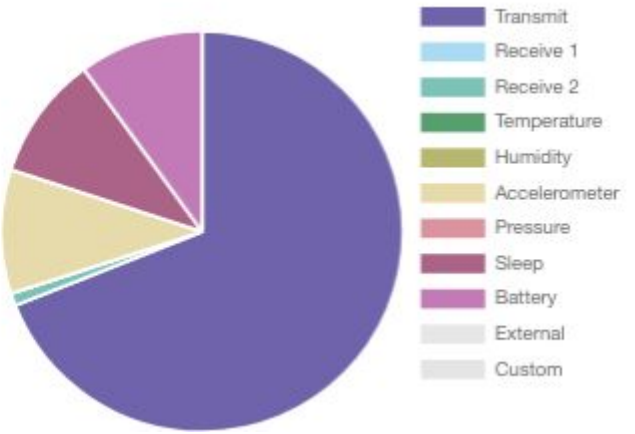
- Battery lifetime from **6** to **18** years (**1 temp. msg/hour**)

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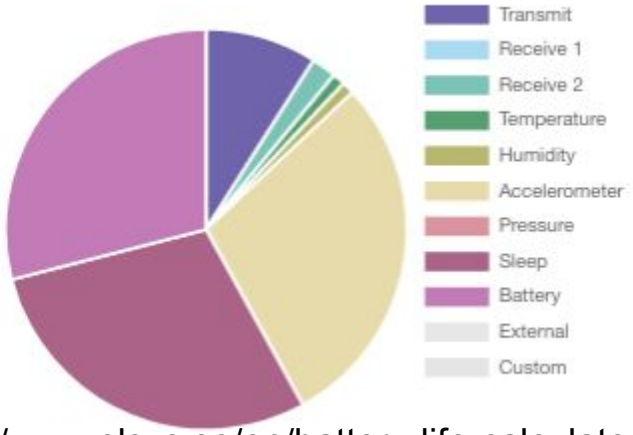
Spreading factor: ◉ SF7 ○ SF8 ○ SF9 ○ SF10 ○ SF11 ○ SF12

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)

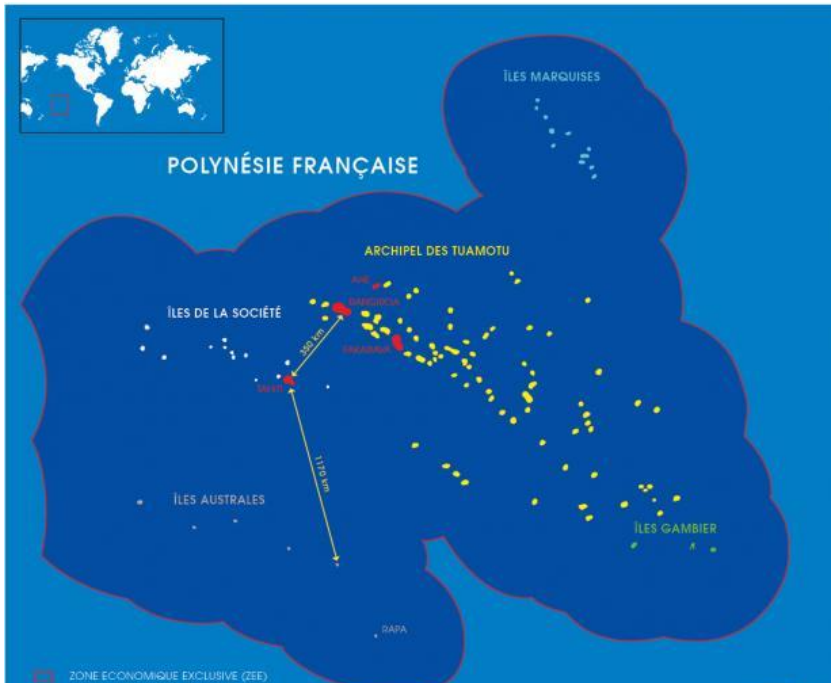
- Mont-Blanc → 300 kms → Strasbourg (Eclipse IoT Days 2018)

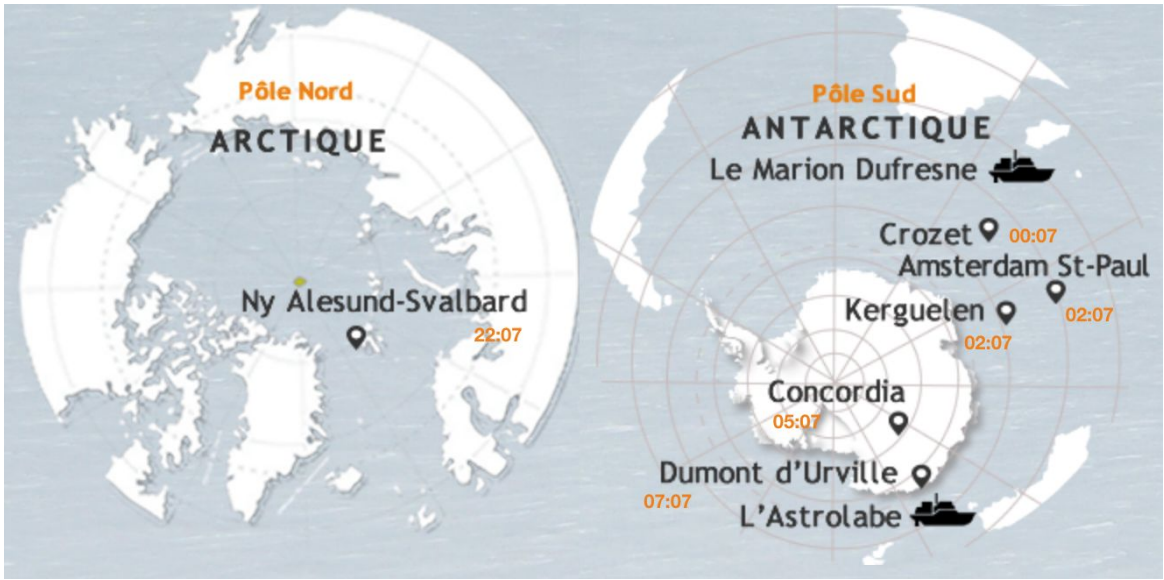
https://wiki.eclipse.org/images/6/62/Eclipse-IoT-Days-Grenoble-2018-MontBlanc-LoRa.pdf

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



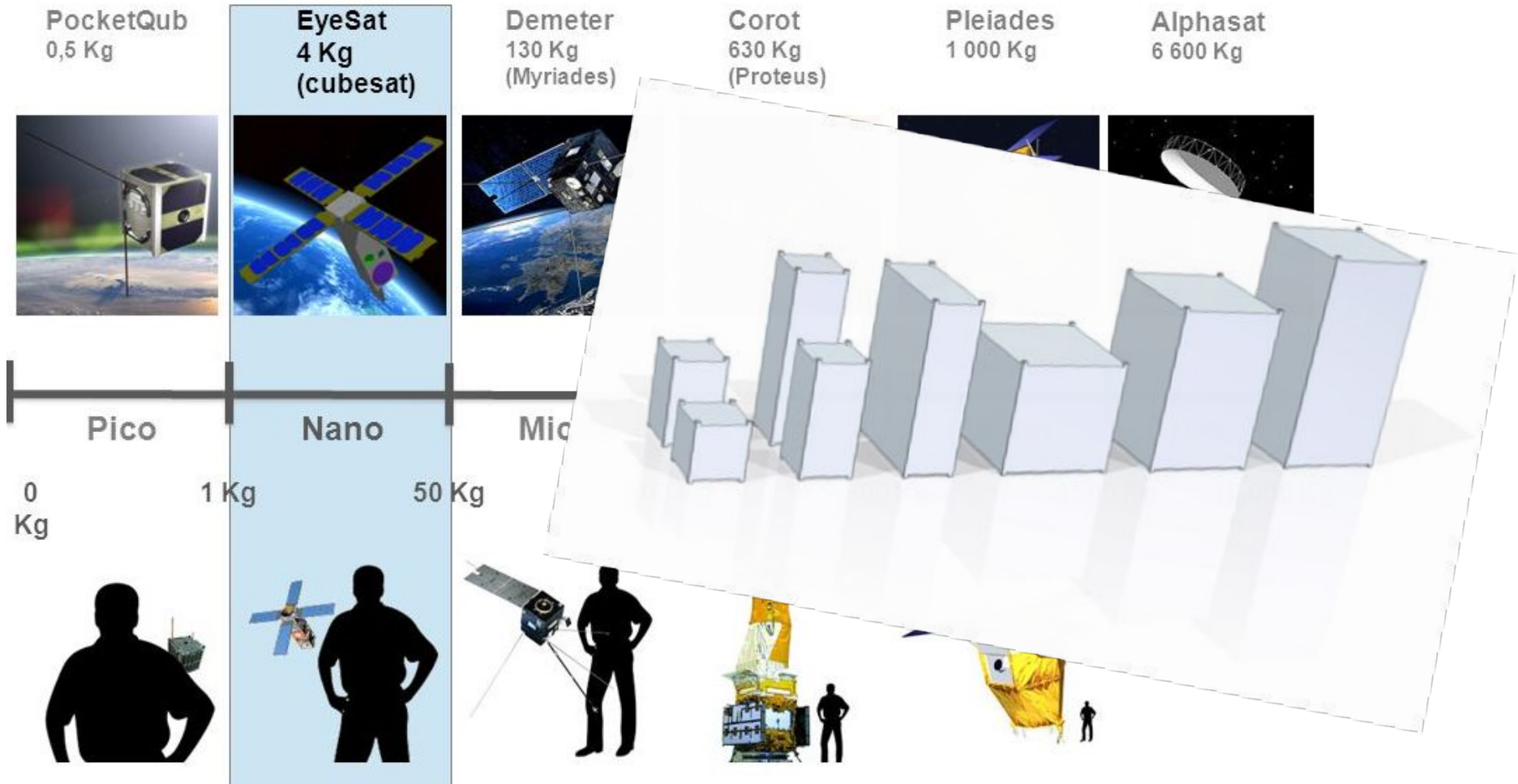


Sat-IoT & LPGAN (i)

- 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, ...

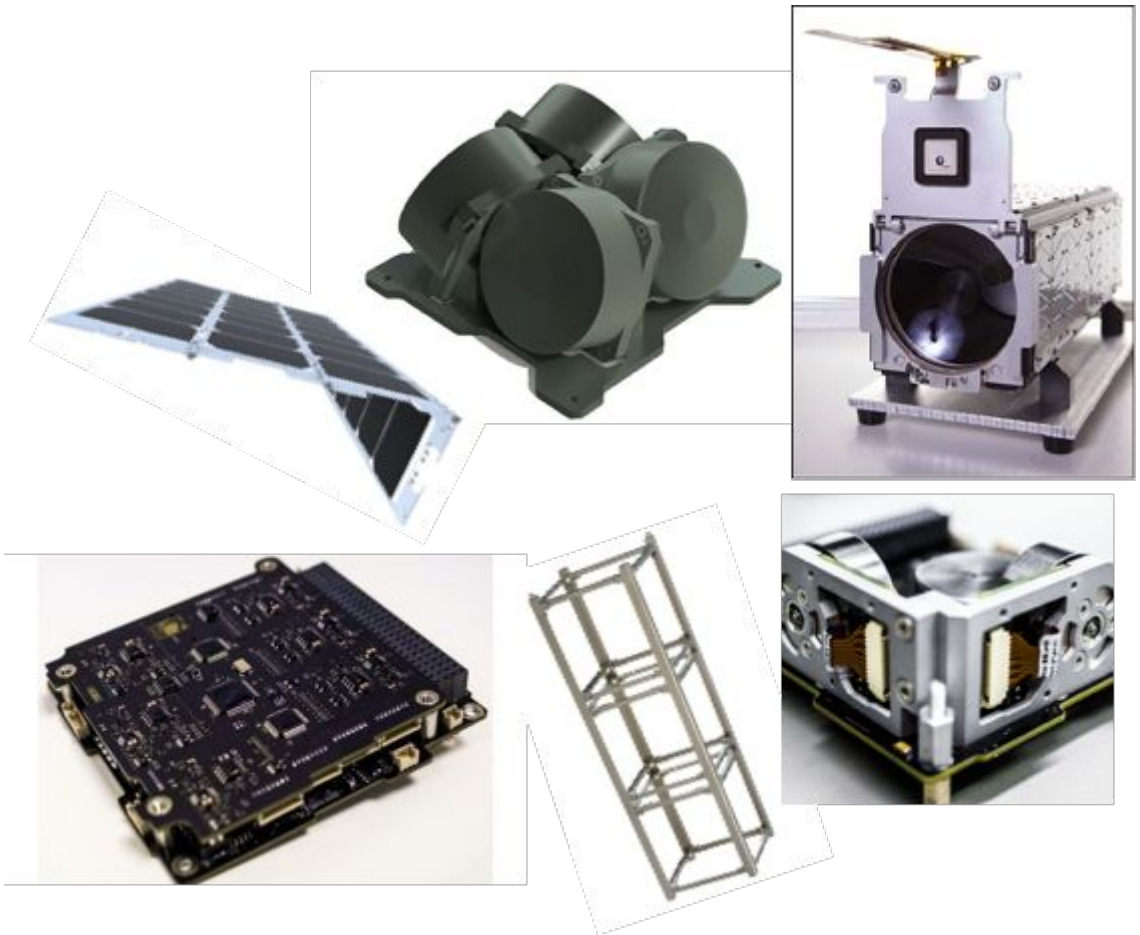
Sat-IoT & LPGAN (ii)

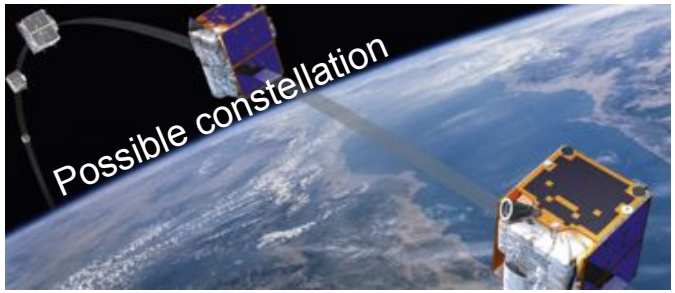
- “New space” & Cubesats
  - Agile and “affortable” LEO satellites



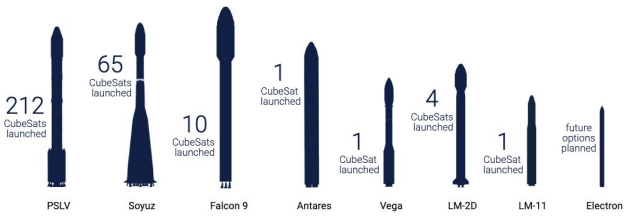
Interest of cubesats

- Component “off the shelf” (Standardized)
- Time development reduction
- Cost reduction
- Launch Vehicle sharing
  - *slot & drop model*





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



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

Sat-IoT & LPGAN (iii)

- LPGAN (Low Power Global Area Networks)
  - Goal
    - Miniatuzed terminals
    - Affortable low power terminals
    - Affortable ground stations
    - Affortable subscription
  - “Affortable” cubesats constellations
  - Affortable network of ground stations

LPGAN Players
Large companies and Startups

- Kinéis (*CLS+Sigfox+Objetnious...*)
- Analytical Space
- Astrocast
- Kepler Communications
- KNL Networks
- Karten Space
- Fleet Space
- HIoTee
- Myriota
- Xingyun
- Blink Astro
- Hongyan
- Hiber (LoRa Alliance Member C00021)
- Lacuna Space (LoRa Alliance Member C00028)
- ... and many more using (nano)satellites in LEO orbits

and us !!! (LoRa Alliance Member C0002B)

us is **CSUG**

Centre Spatial Universitaire de Grenoble

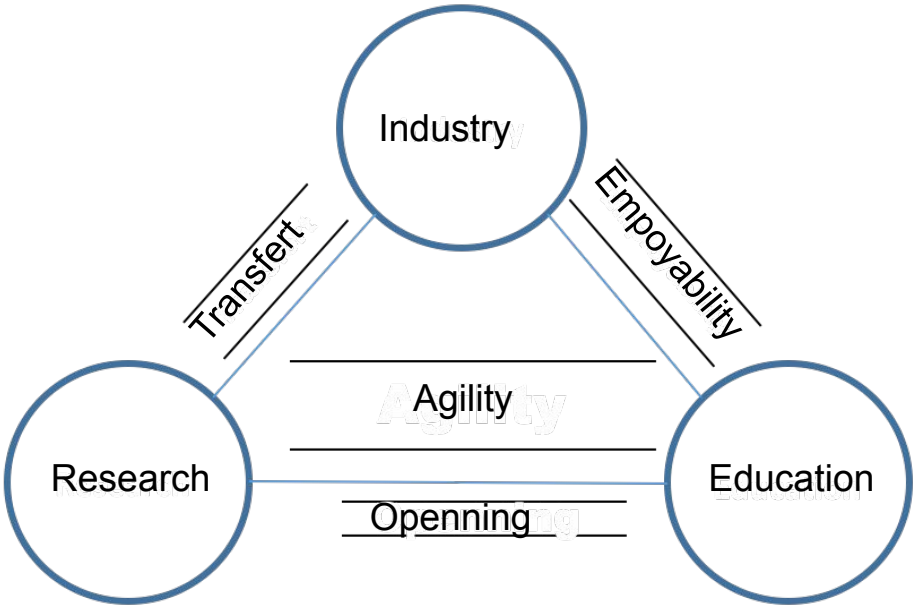
From miniaturised payloads to uses

Application domain

Earth Observation
Space weather
QKD

Prospectives 2020

IOD/IOV
Communications
Exobiology



AMICAL Sat: Q2 2019

ATISE: 2021

NanoBOB: TBD

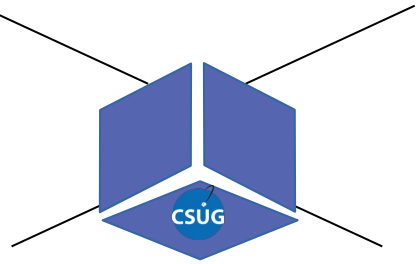
NanoCARB Collaboration: 2021

ThingSat 2021

ESA D3S WFAI: 2023-2026

Blob in Space: 2024

The ThingSat project of CSUG



Research vehicle for

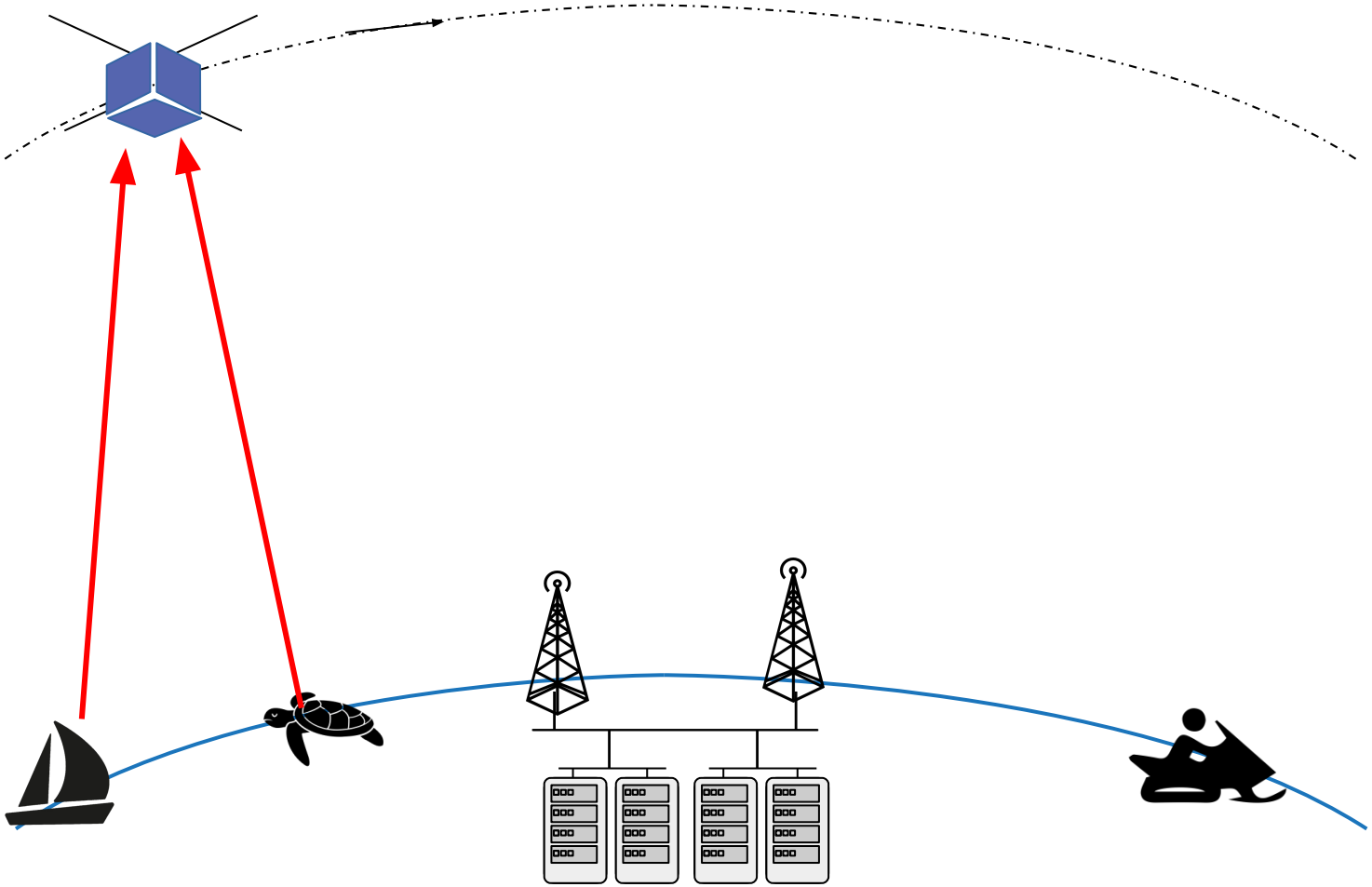
1) Testing LoRa-based modulation for
- ground station ←→ cubesat communications
- end-point ←→ cubesat communications
- cubesat ←→ cubesat communications

2) Testing applications
- delay tolerant networks EP ←→ CS ←→ GS
- multi-lateration of EP
- clock distribution
- track and monitor “zombie” or EoL satellites

Communication principles for IoIT

Delayed Tolerant Network

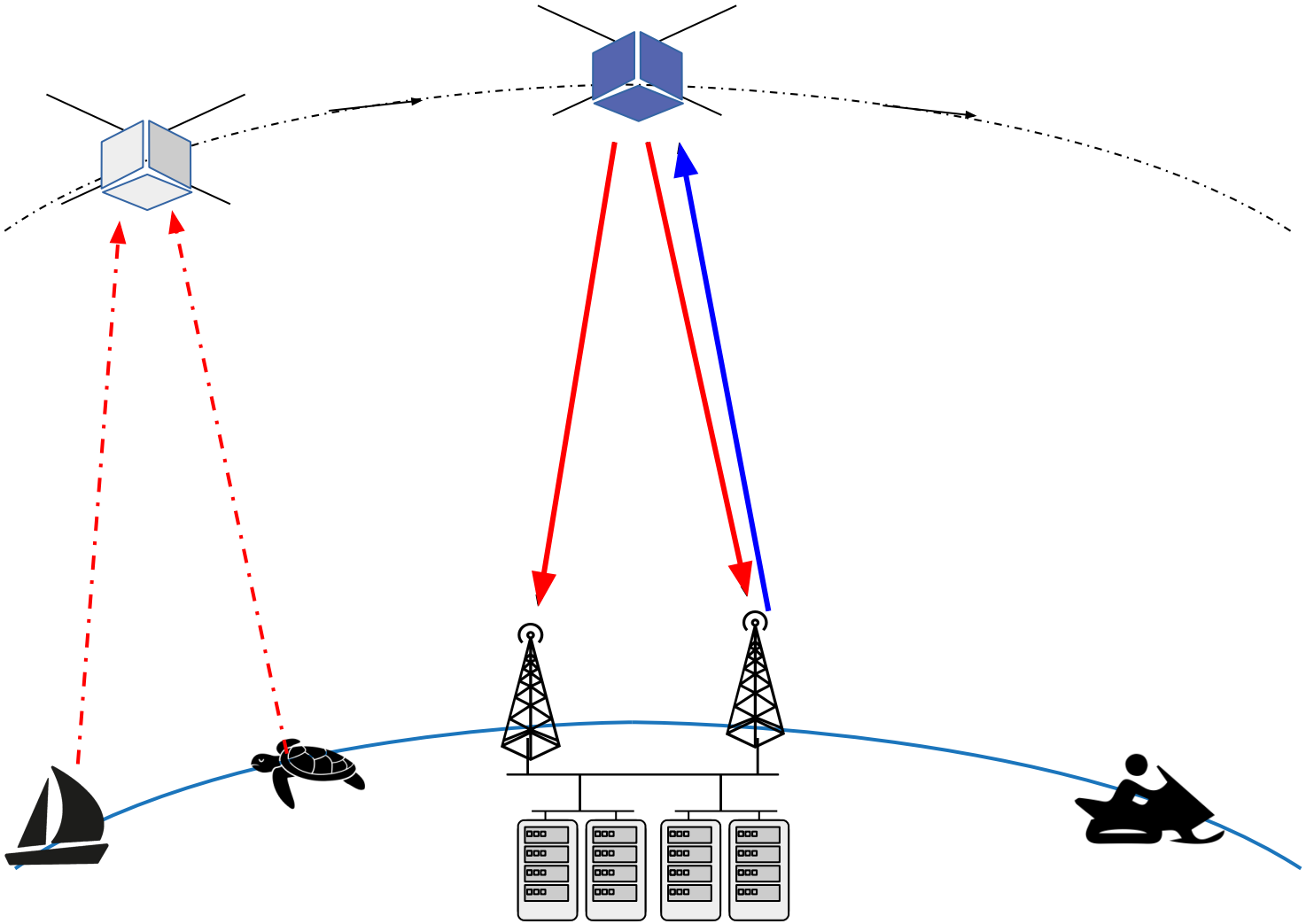
How does it work : Store & Forward LoRa frames



Communication principles for IoIT

Delayed Tolerant Network

Cub-Sat is a data « mule »



Communication principles for IoIT

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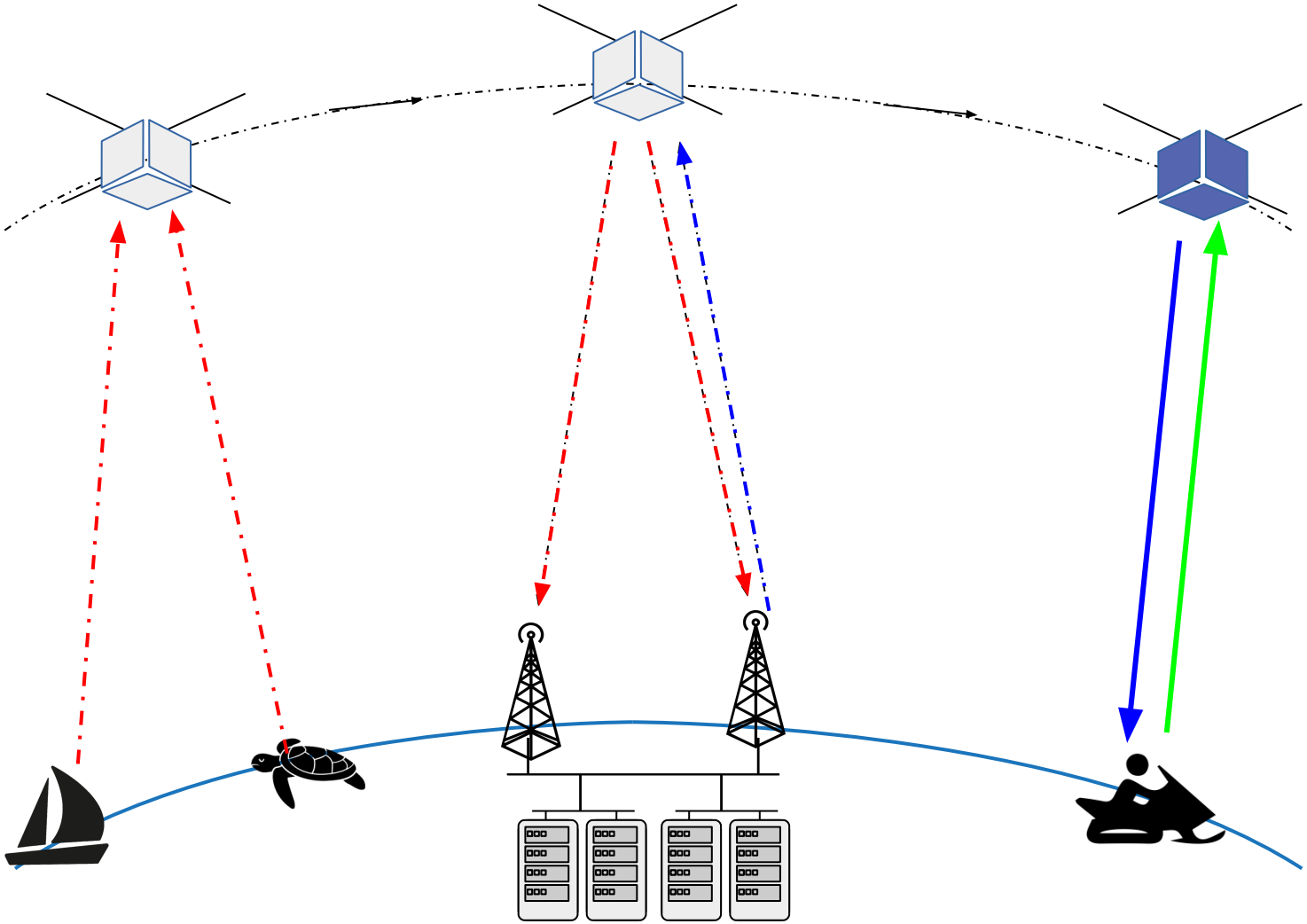

Communication principles for IoIT

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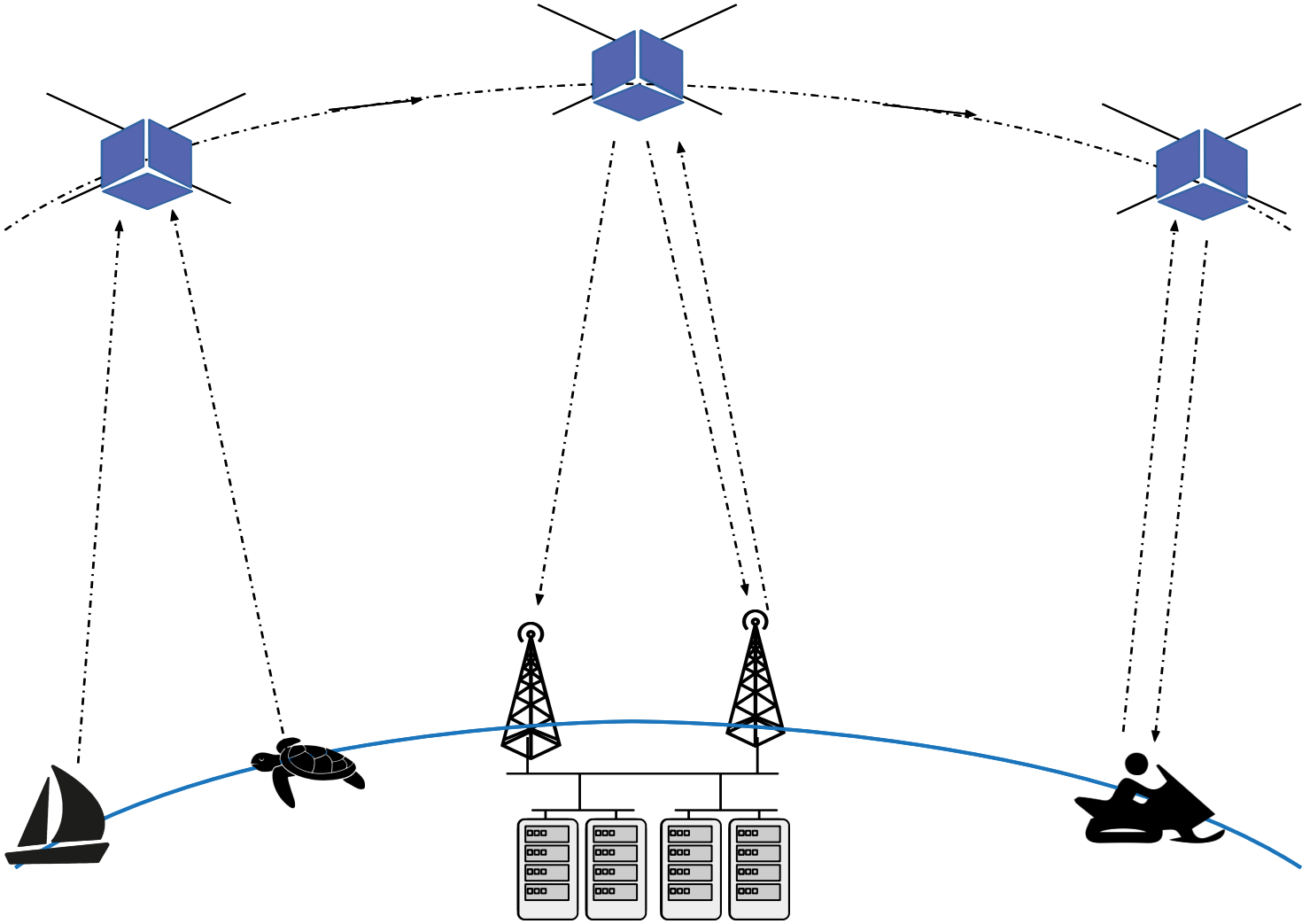


Planned field tests and use cases

- Col du Lautaret
  - Alpine ecology/biology
- Svalbard (Spitzberg)
  - Rescue operation
  - Scientific instrumentation
- Polynésie Française (Pacific ocean)
  - ZEE (Exclusive Economic Zone): 5 millions km²
  - Fish farming, Tide-gauge
- Air liquide
  - Helium bottle tracking (pressure, temperature, …)

Preliminary radio tests
LoRa in the Near Space

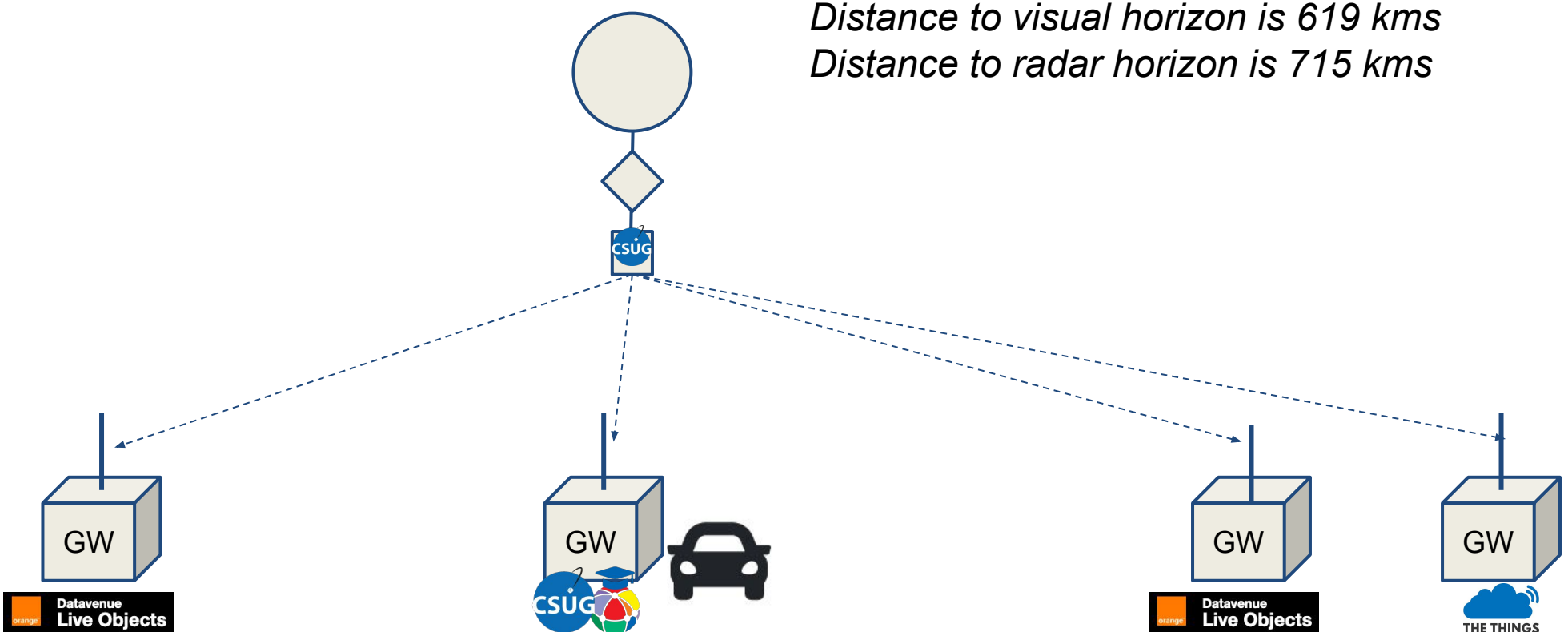
Goal

- Benckmarking LoRa™ modulation link margin and distance per LoRa radio parameters (TxPower, SF and BW)

How

- EP into a sounding balloon (up to 30000 meters of altitude)

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



Preliminary radio tests
LoRa in the Near Space

Our endpoint

- *Off-the-Shelves* board (STM32+SX1272+GPS)
  - RIOT OS
  - ADR is off. Transmit frames with various combinaisons of SF (7 .. 12) and TxPower (2 .. 19)
  - SF, TxPower, Temperature, GPS (latitude, longitude, altitude)
- Registration on multiple LoRaWAN Networks
  - Orange LiveObject (5500 gateways with/without TDOA in France)
  - The Thing Network (+4700 gateways in Europe)
  - CampusIoT (1 mobile gateway in a car roof top)
- Live tracking with NodeRED (GPS, TDOA)

Max link budget = **157** dB

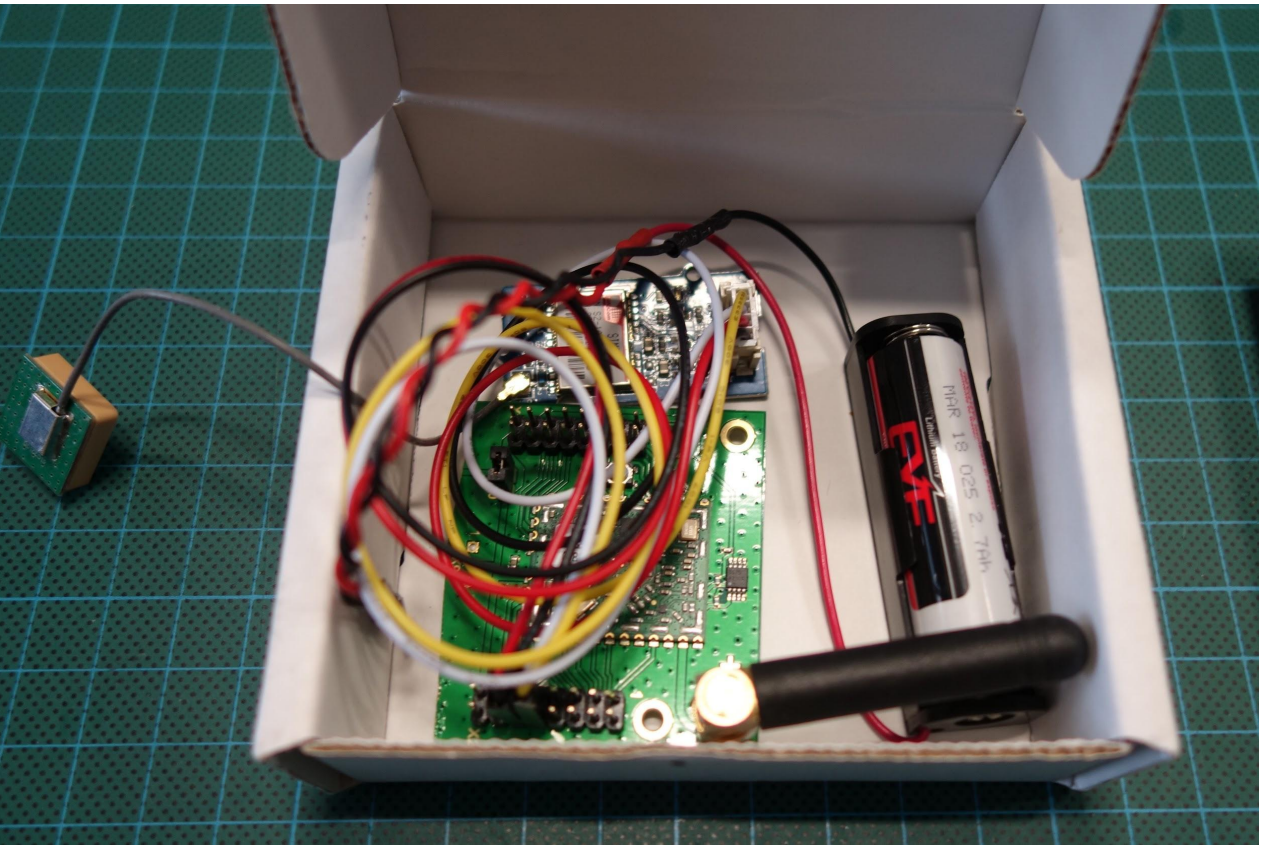
Datavenue Live Objects

THE THINGS NETWORK

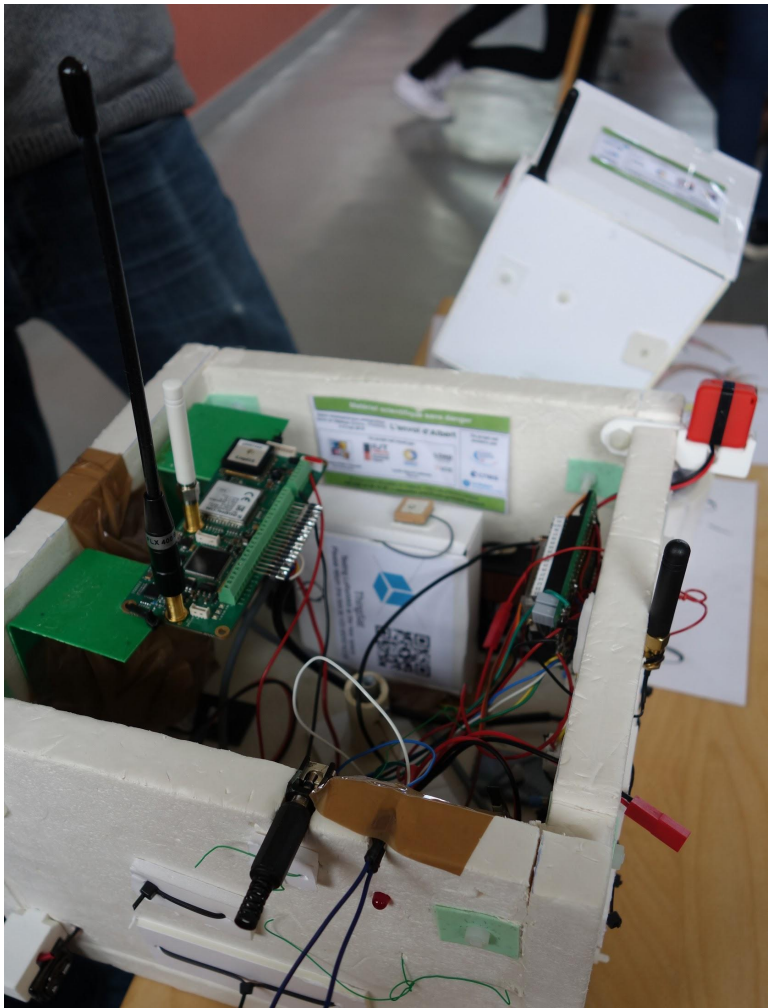
Flight #1
“L’envol d’Albert”, May 9th, 2019

Planète Sciences, CNES
IUT Valence, Lycée Triboulet (Roman/Isère), Collège Roman

80 grams



1800 grams max



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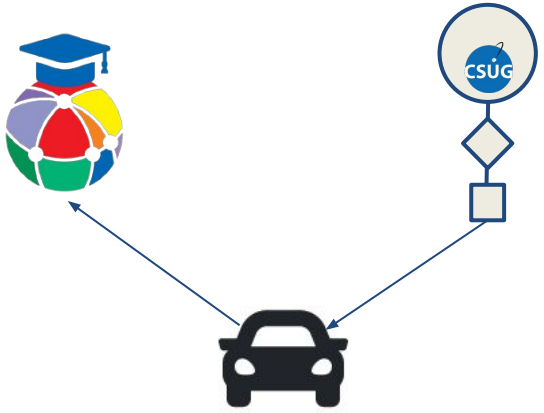

LoRa Sniffer Car

Flight #1
“L’envol d’Albert”, May 9th, 2019

Valence (26) → 140 kms (2h30) → Méolans-Revel (04) à 2200m alt.
Weather conditions: cloudy

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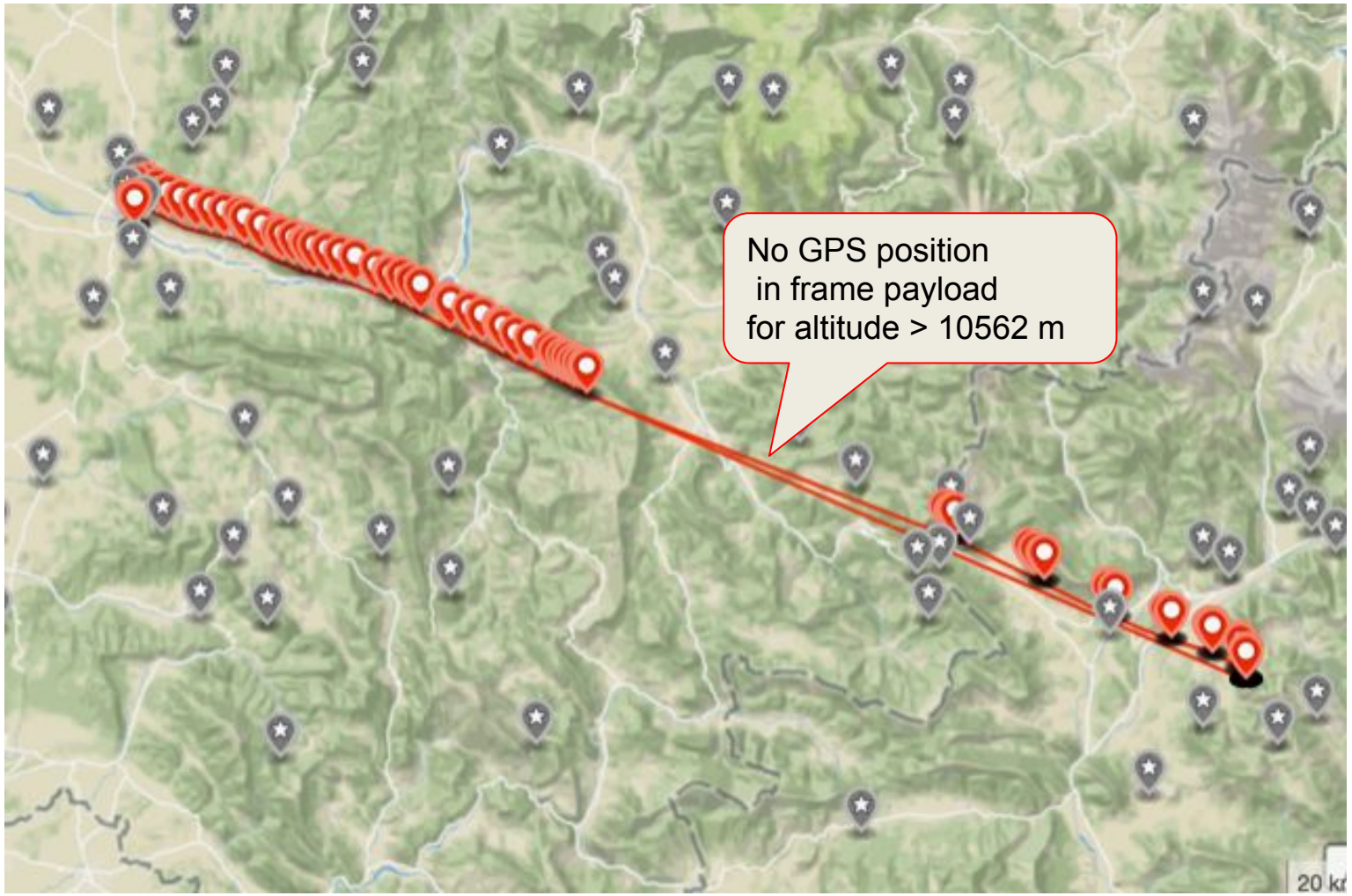

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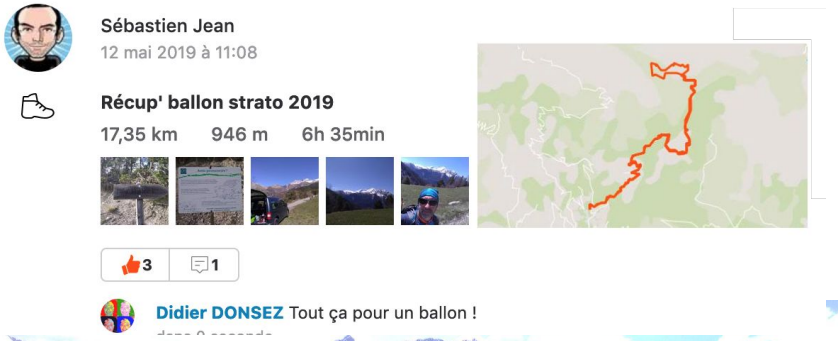
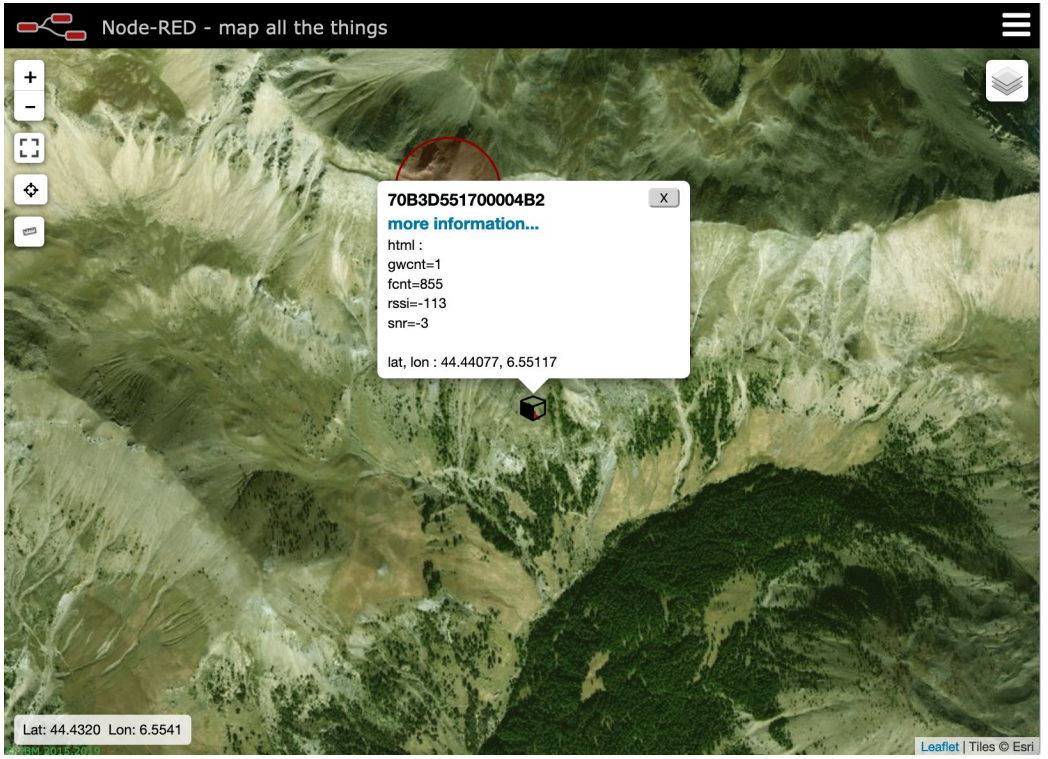
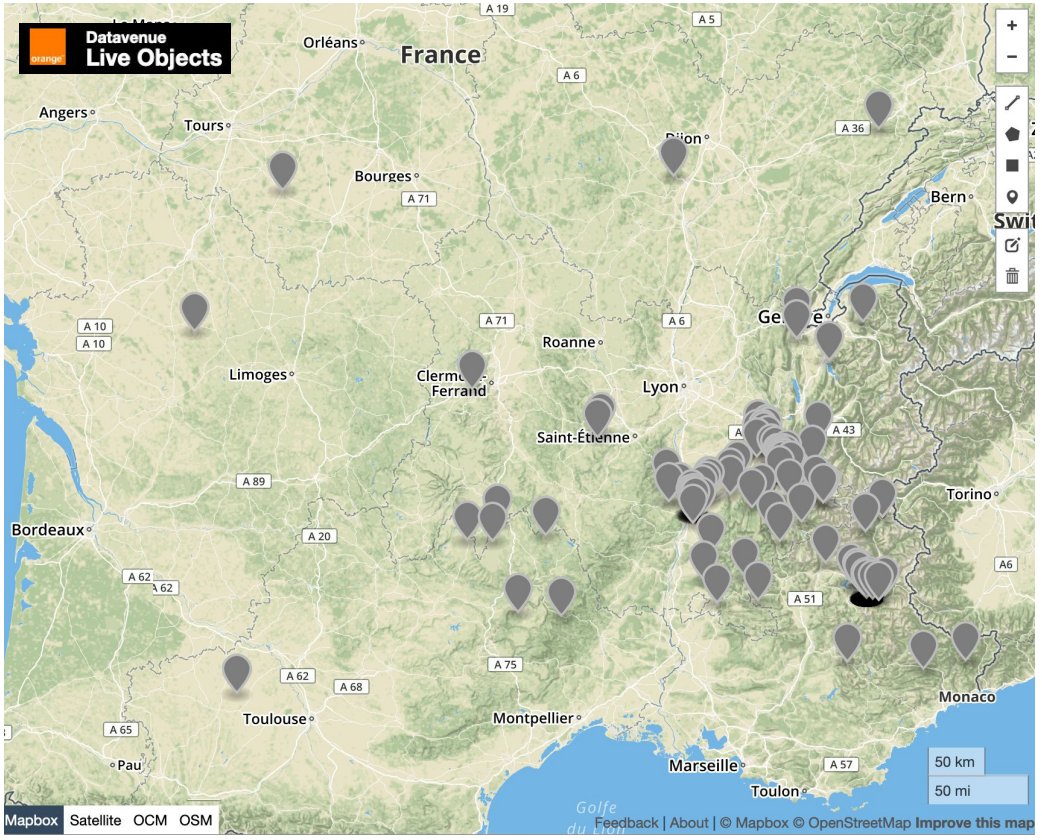




LoRa in the Near Space
Preliminary results of flight #1

Distance, RSSI/SNR, Packet Error Ratio (per SF and per Tx Power)
UNDER ANALYSIS (550 kms on TTN, 400 kms with Orange LiveObject)



LoRa in the Near Space
Datasets of flight #1

3 jeux de données hétérogènes
- pas mal de nettoyage, d'inférences …
- manque de *datavizers*

Payload incomplet
- GPS < 11000m, pas de pression atmosphérique

Orange
- que les 10 meilleurs gateways (non positionnées)
- timestamp nanosec + TDOA 2D

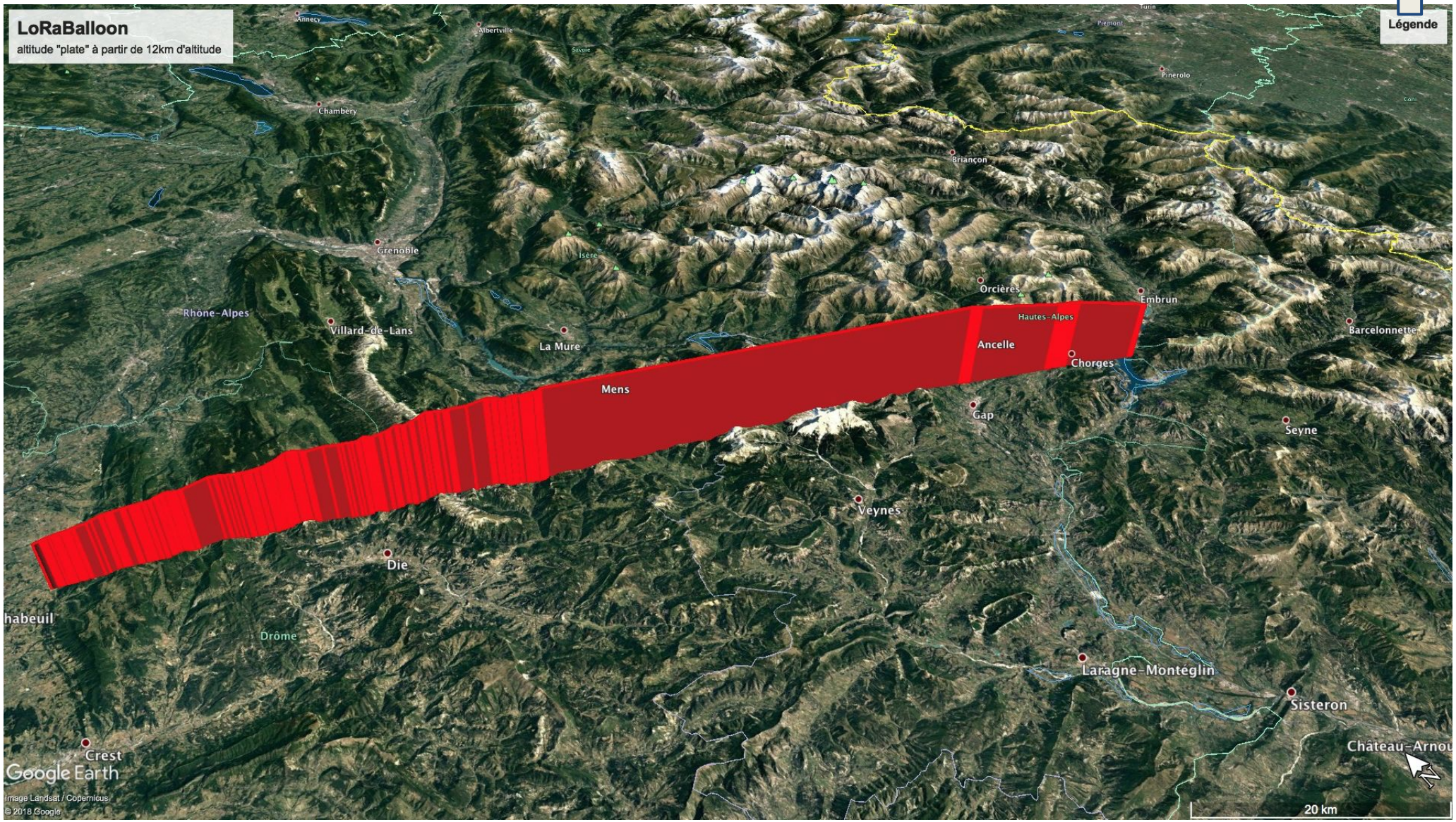
TTN
- souci à l'enregistrement des endpoints "virtuels"

CampusIoT
- portion du trajet
- boite de fusible de rechange

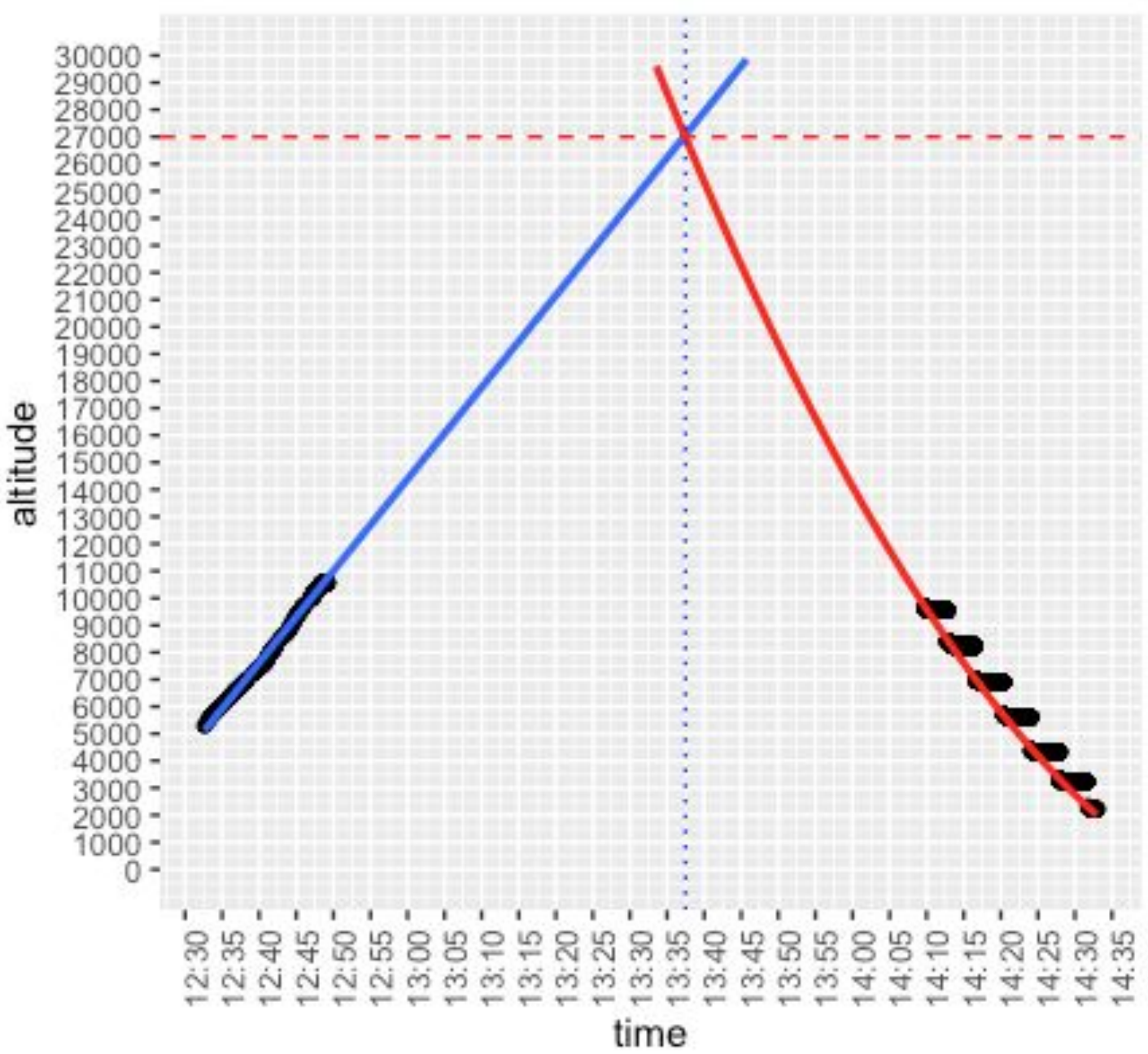
LoRa in the Near Space
Analysis of flight #1

Olivier, à toi la parole !

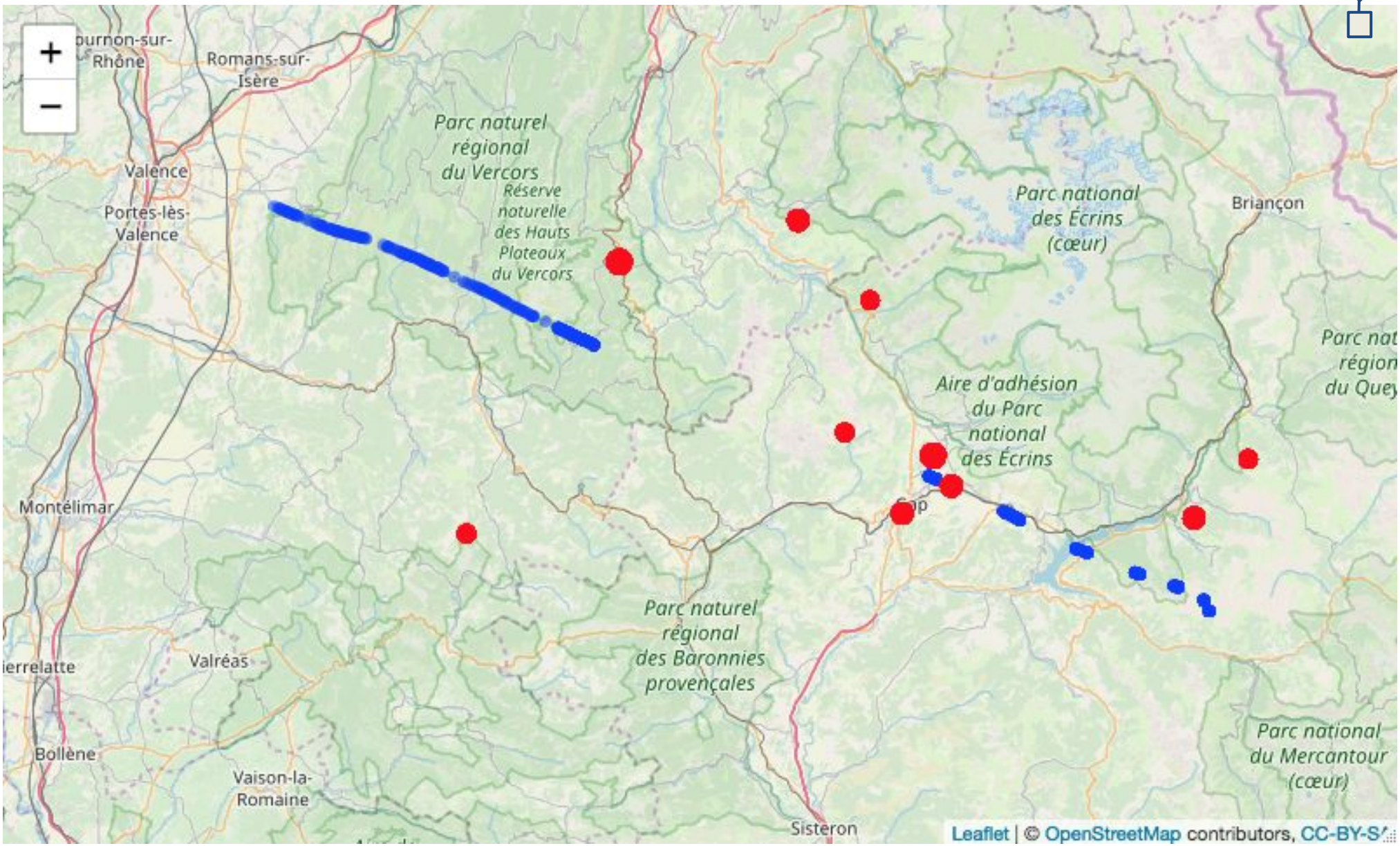
Trajet (Google Earth)



Altitude vs time



Top 14 gateway LoRa



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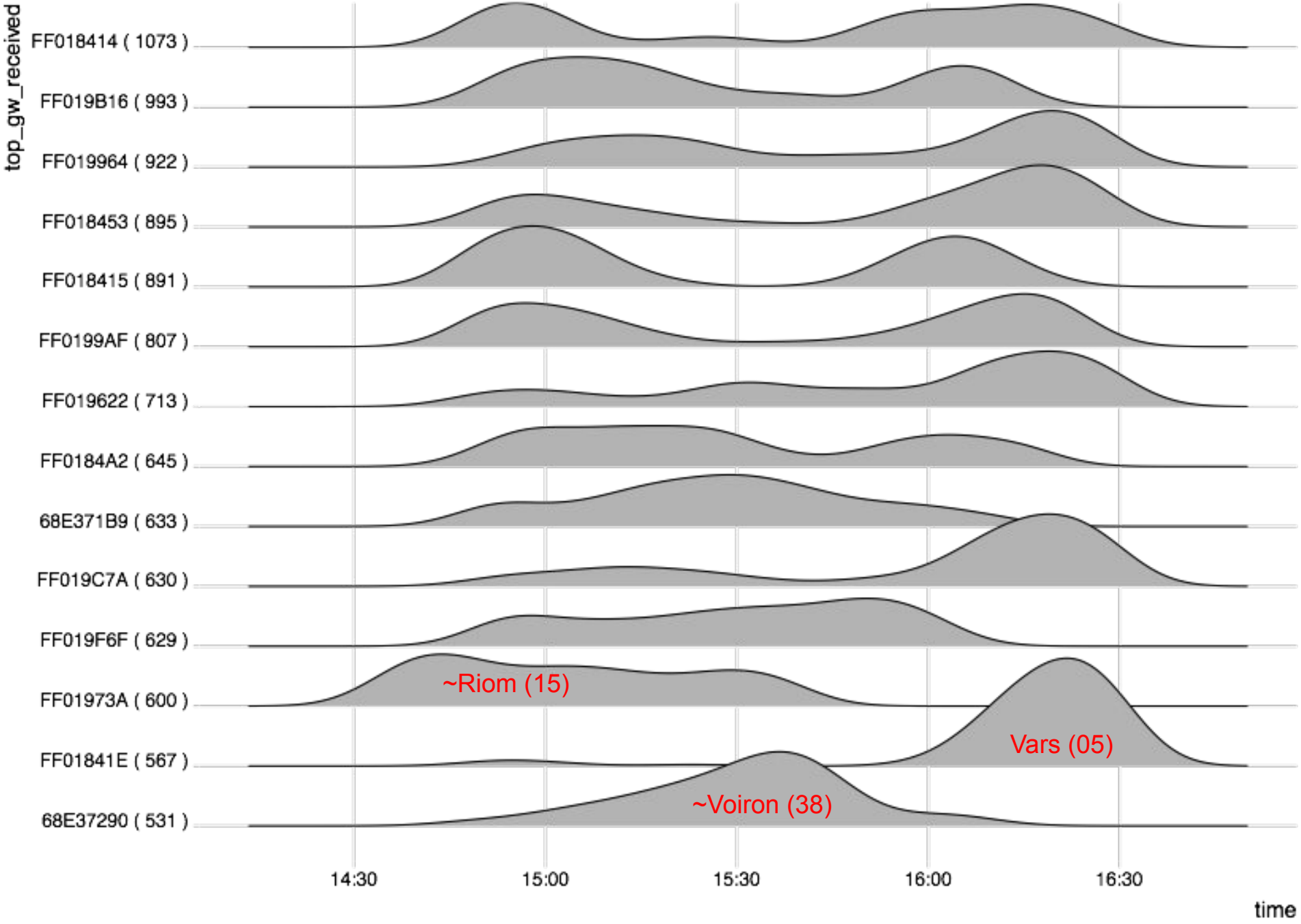
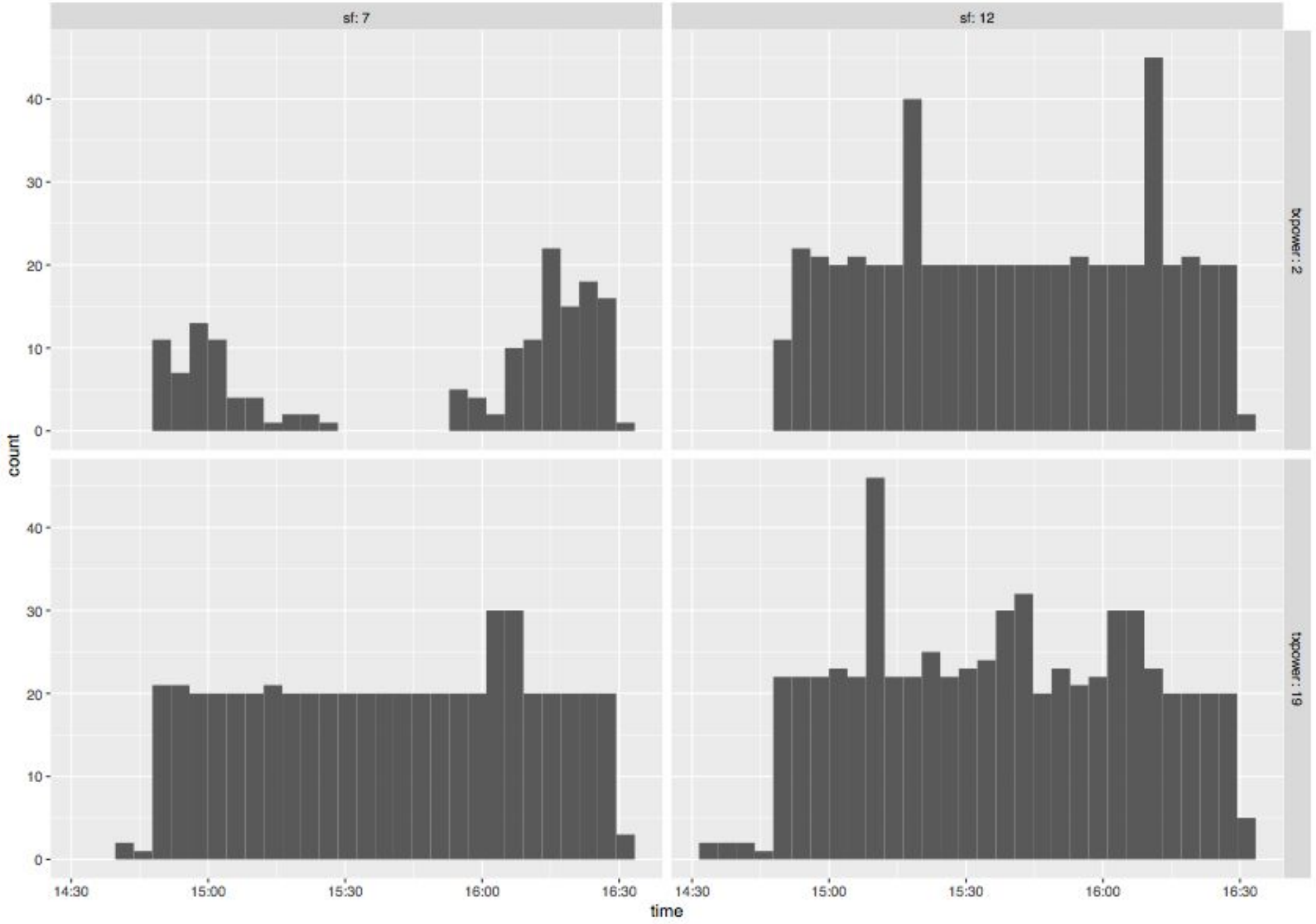
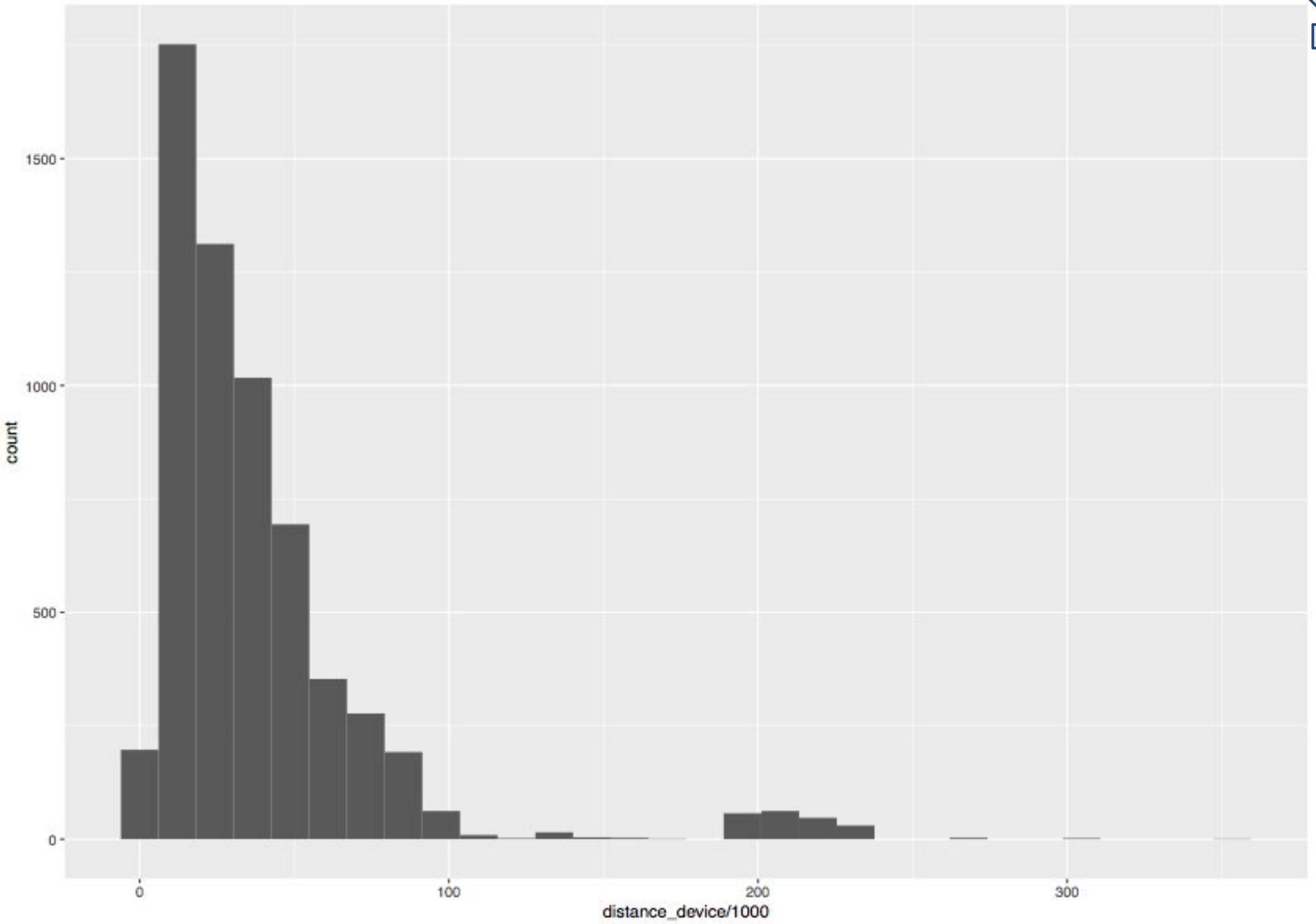


Distribution temporelle des paquets reçus



Distribution des distances



Sent packets

	2	5	8	11	13	15	17	18	19	total power
7	64	64	64	62	64	64	64	64	64	574
8	64	64	64	62	64	64	64	64	64	574
9	64	64	64	62	64	64	64	64	64	574
10	64	64	64	62	64	64	64	64	64	574
11	64	64	64	62	64	64	64	64	64	574
12	64	64	64	63	63	64	64	64	64	574
total SF	384	384	384	373	383	384	384	384	384	3444

Packet Delivery Ratio

	2	5	8	11	13	15	17	18	19	total power
7	59	80	91	90	89	88	88	89	91	85
8	78	86	91	90	94	91	91	91	92	89
9	83	88	92	95	95	91	94	94	98	92
10	88	88	95	97	97	97	98	95	97	95
11	88	89	98	95	95	98	98100		98	96
12	88	92	94	98	97	95	97	98	98	95
total SF	80	87	93	94	95	93	94	95	96	92

Conclusion & Perspectives

- Looking for funding a 1U or 2U ThingSat cubesat
- Targetting a launch into orbit on Q1 2021
- Toward free and open-source community
  for LPGAN technologies (SW/HW)
  - https://github.com/CampusIoT/orbimote
- Toward an open community of users
  - end-points owners
  - low-cost* ground station owners (volunteers)

Soon on github.com/ThingSat

* starting at 200 $ antenna incl.

Q & A

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DE LA POLYNÉSIE FRANÇAISE

Bonus track

http://astra-planner.soton.ac.uk/