ThingSat:

an in-orbit research vehicle for experimenting SatIoT

03/09/2026

Charlélie PIGNOL & al
UGA - Grenoble INP - Floralis
LIG Drakkar & CSUG

Project Team & Partners

Grenoble University Space Center (CSUG)

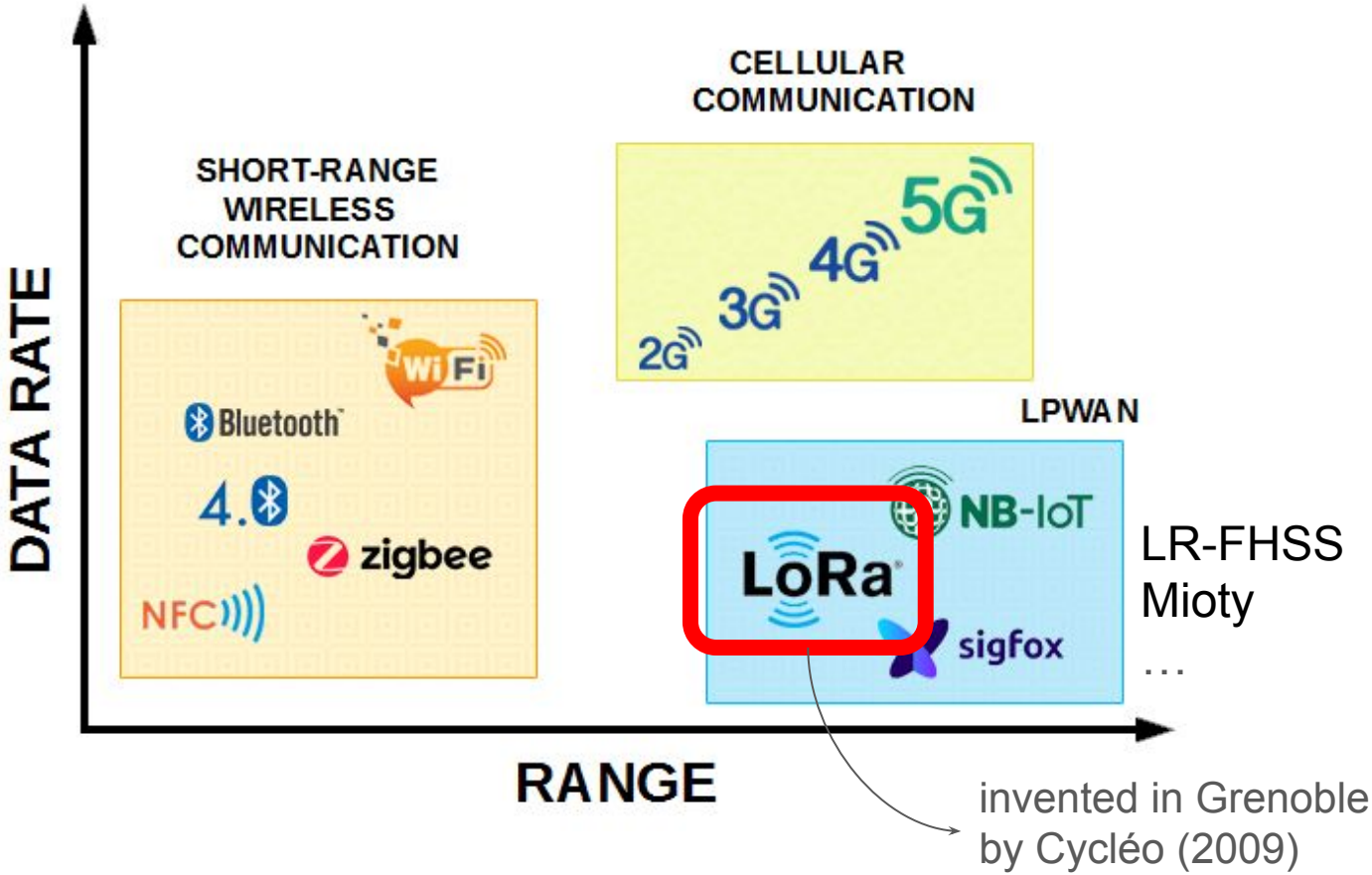
Computer Science Laboratory of Grenoble (LIG)

Centre for Radiofrequencies, Optics and Micro-nanoelectronics in the Alps (CROMA)

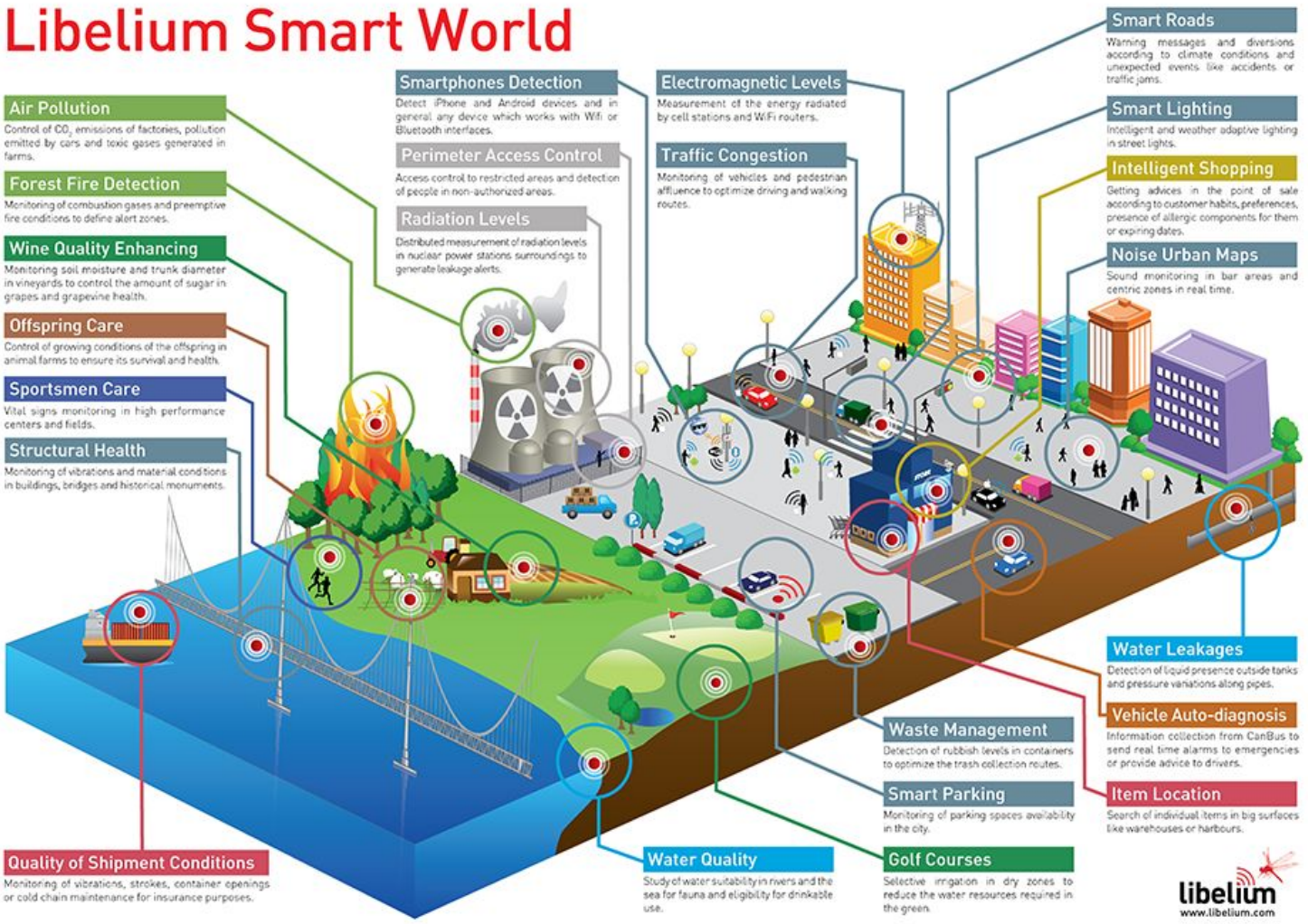
The IoT Paradigm

Connecting thousands of low-cost, battery-operated sensors to collect actionable data.



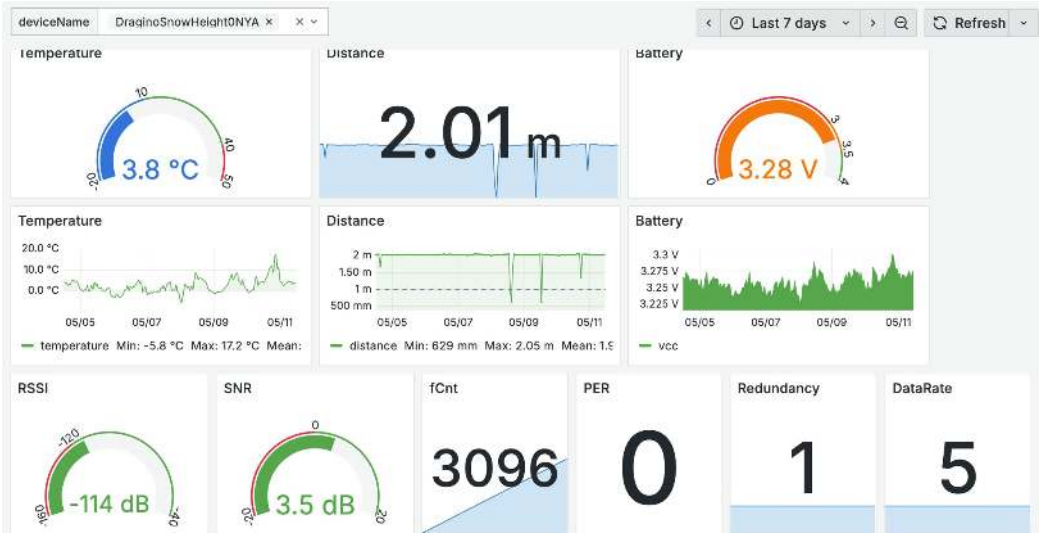


IoT Applications



From extrem IoT





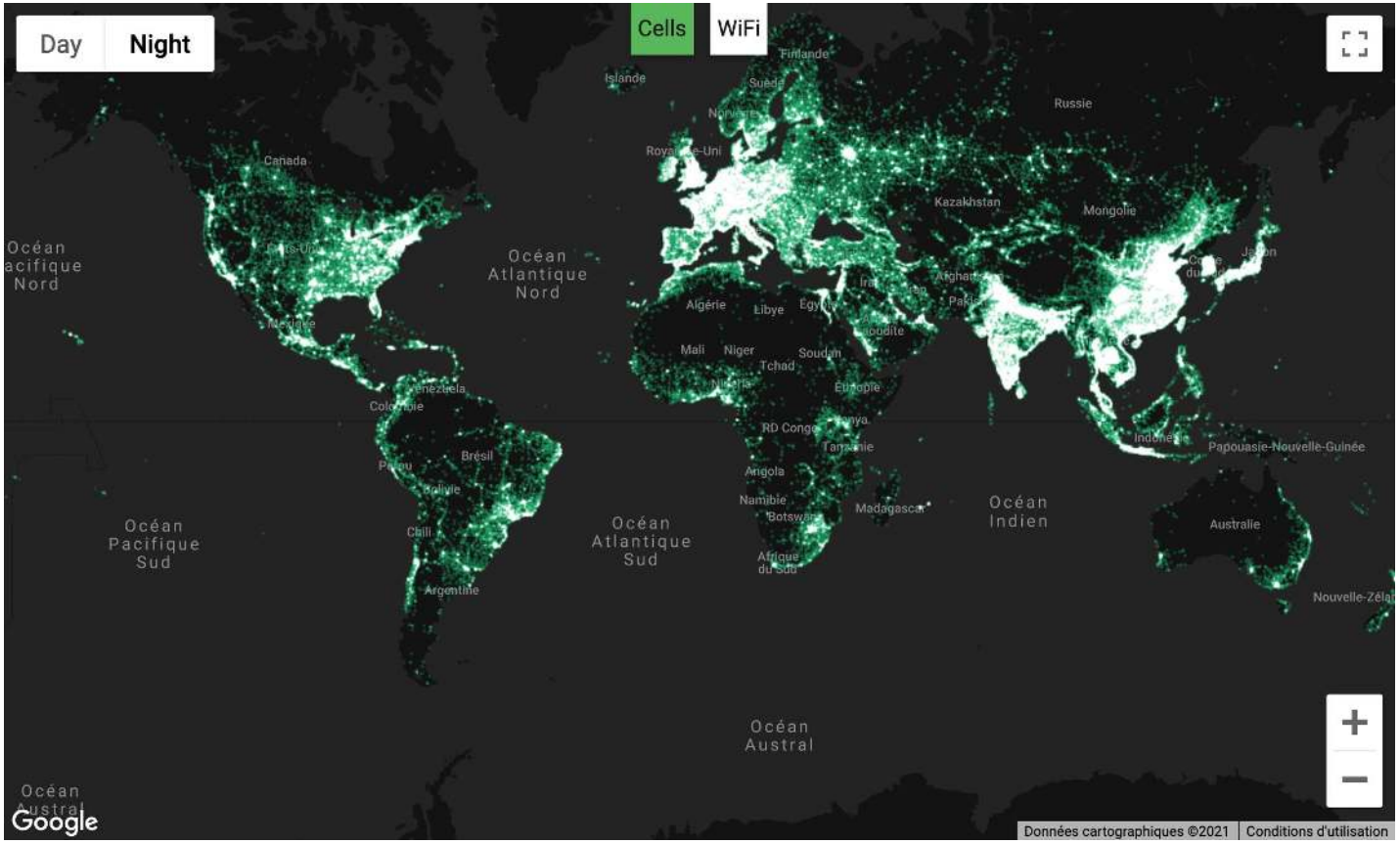


JM Friedt @ Corbel, Svalbard



To IoT for isolated objects

Terrestrial IoT networks stop where human infrastructure ends.

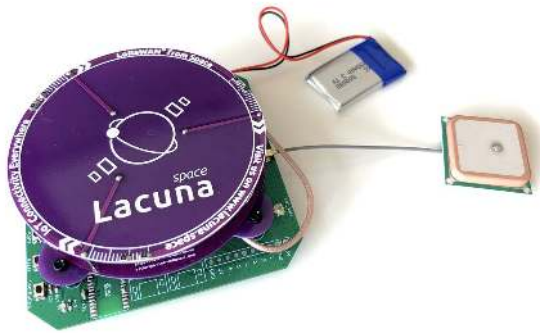


From LPWAN to LPGAN (or SatIoT)

- Satellite constellation (fat or nano) forwarding IoT messages from/to isolated endpoints
- SatIoT operators (*LoRaWAN, NB-IoT, Mioty …*)
  - LEO: Lacuna Space, Astrocast, Kineis, Fossa, …
  - GEO: ~~Echostar Mobile~~, …







credits: Lacuna space, Kineis

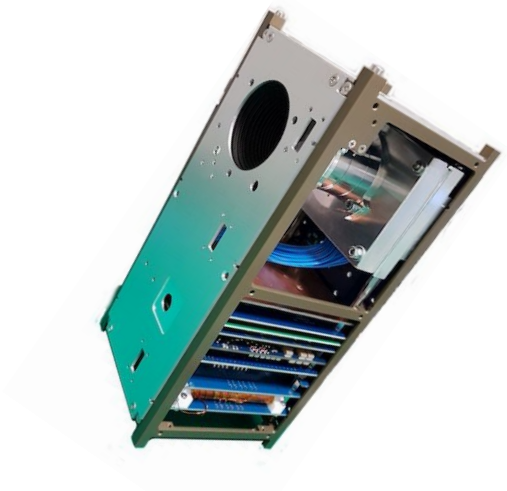
The NewSpace Revolution

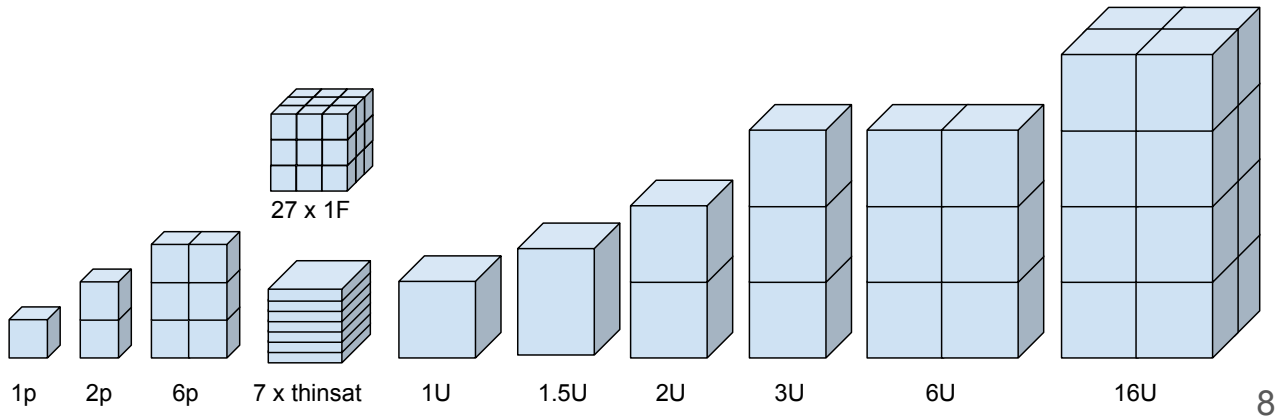
Emerged around 2004, driven by private pioneers (SpaceX, Rocket Lab) and the standardization of the CubeSat format.

Transitioning from traditional multi-million-dollar satellites to “low-cost” CubeSat constellations (1U–6U).

Reducing mission design and deployment timelines from 10+ years to under 2 years.

Using industrial-grade hardware over expensive radiation-hardened hardware.





Satellite IoT (SatIoT)

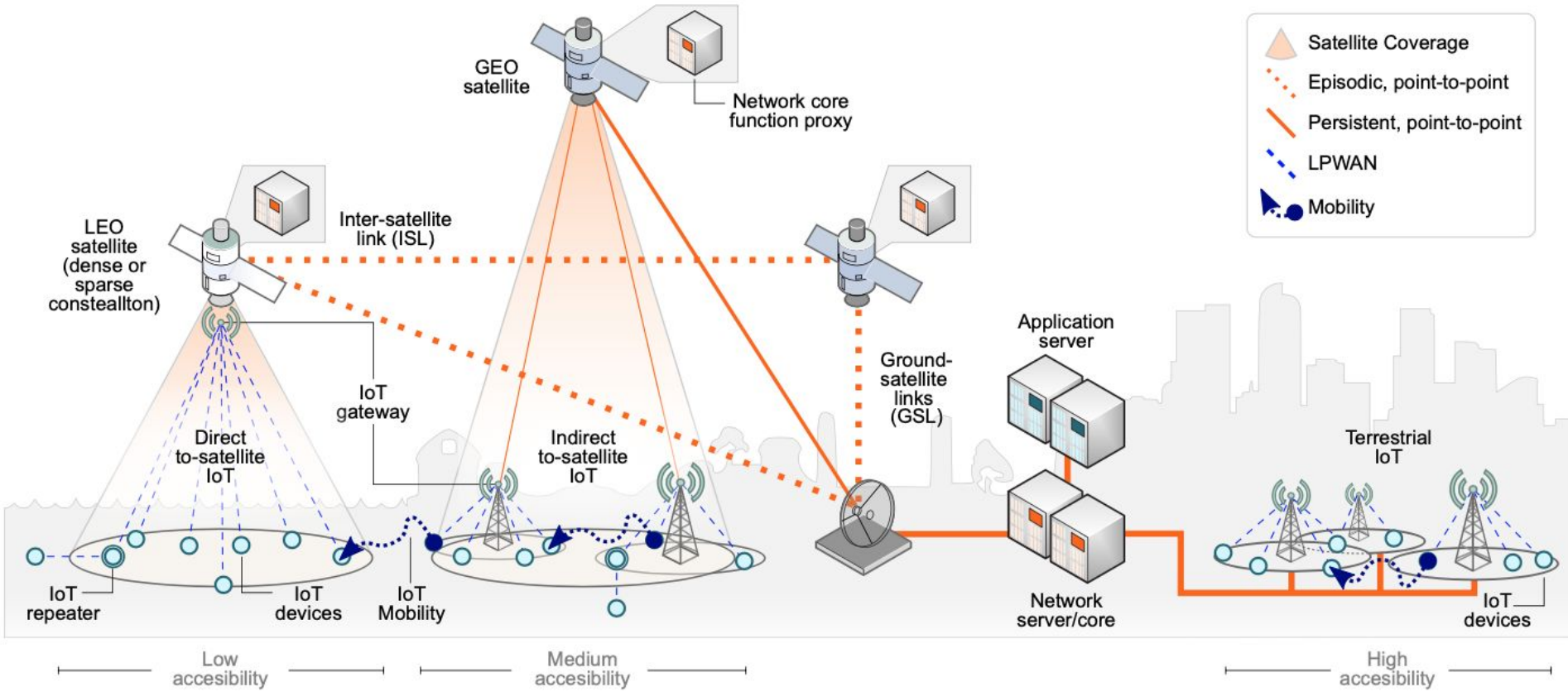


Figure from [Fraire et Al, « Space-Terrestrial Integrated Internet of Things: Challenges and Opportunities ». IEEE Communications Magazine 60, nº 12 (décembre 2022)]

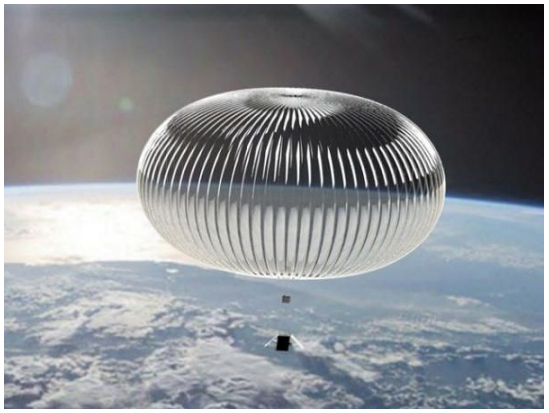
and HAPS IoT

High-Altitude Pseudo-Satellites / Platform Stations operating at 20 to 30 km altitude (stratosphere).

Continuous flight over targeted regions for weeks to months.

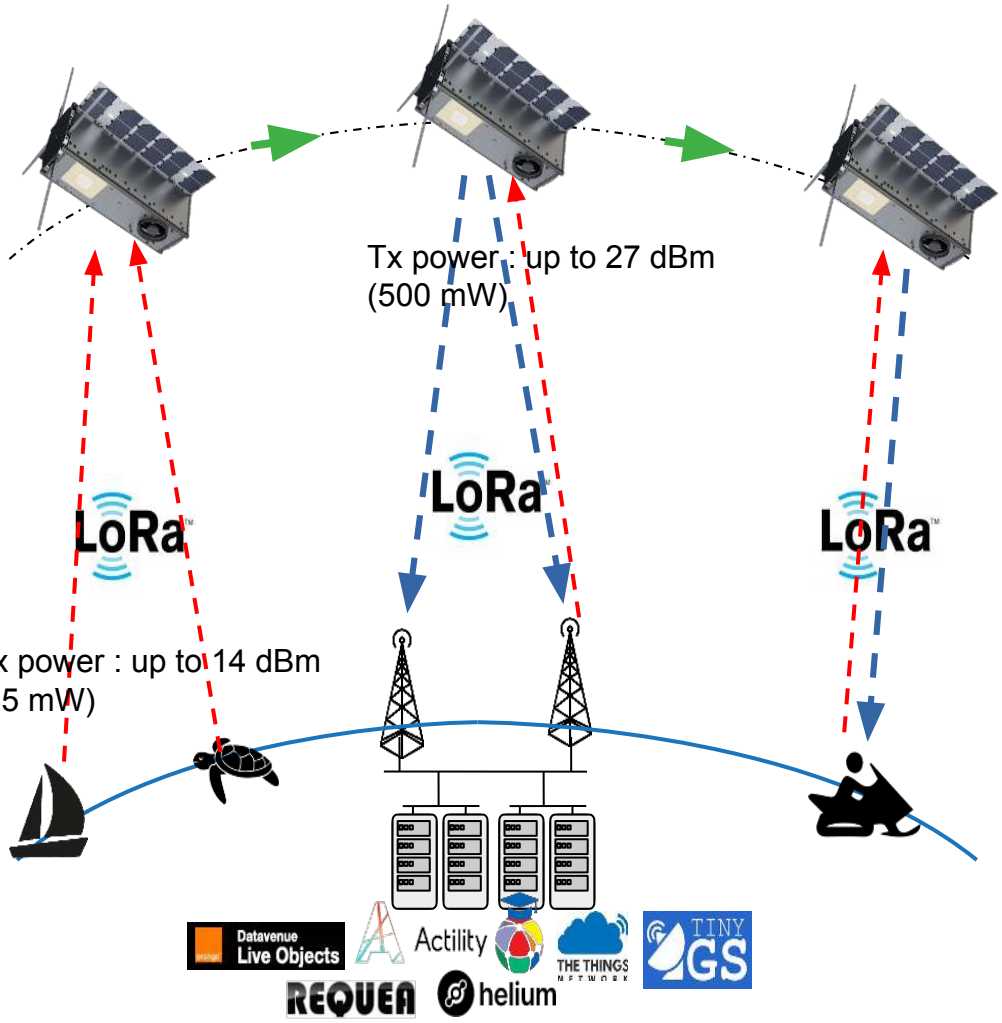
Earth observation, disaster, environnemental surveillance

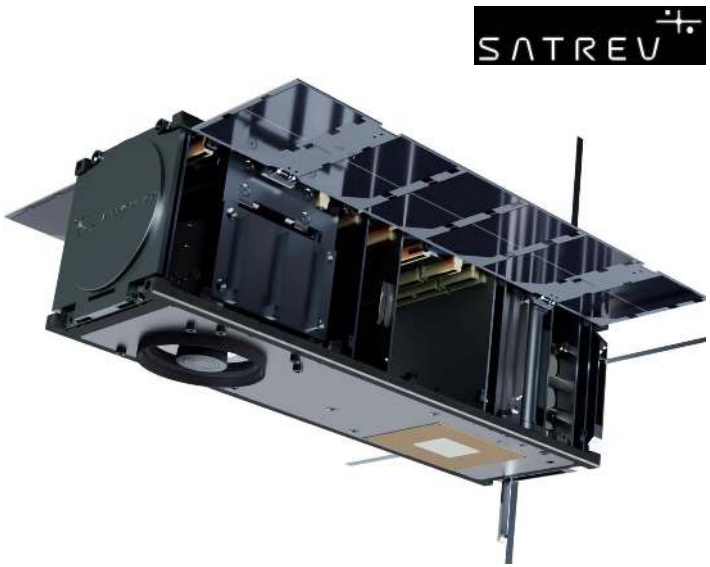






ThingSat : NewSpace LoRa gateway for Isolated Internet Of Things









ThingSat saga

Mission 0 : 2020 to now

CNES stratospheric balloons

- Testing, validation, experimentation

Mission 1: 2022

SatRev Satellite (POL)

- Polish industrial partner
- Launched by SpaceX in January 2022
- Loss of the satellite due to a solar storm

Mission 2: 2026

SatRev Satellite (POL)

- Polish industrial partner
- Launch scheduled for October 2026 by SpaceX
- Integration validated into the flight model (FM)

Mission 3: 2027

Dhruva Space Satellite (IND)

- Indian industrial partner
- Launch scheduled for 2027/2028

Mission 4: 2027 to 2029

5-Satellite COMETES Constellation (FR)

- Integration into 5 university satellites
- Launch scheduled between Q1 2027 and Q4 2029

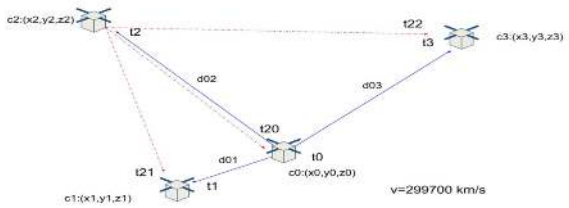
Use Cases

Store-Carry-and-Forward mechanisms for sensor data delivery (COMETES, Terraforma, IPEV, …)

Off-grid LoRa mesh repeater (Meshcore, Meshtastic, …).

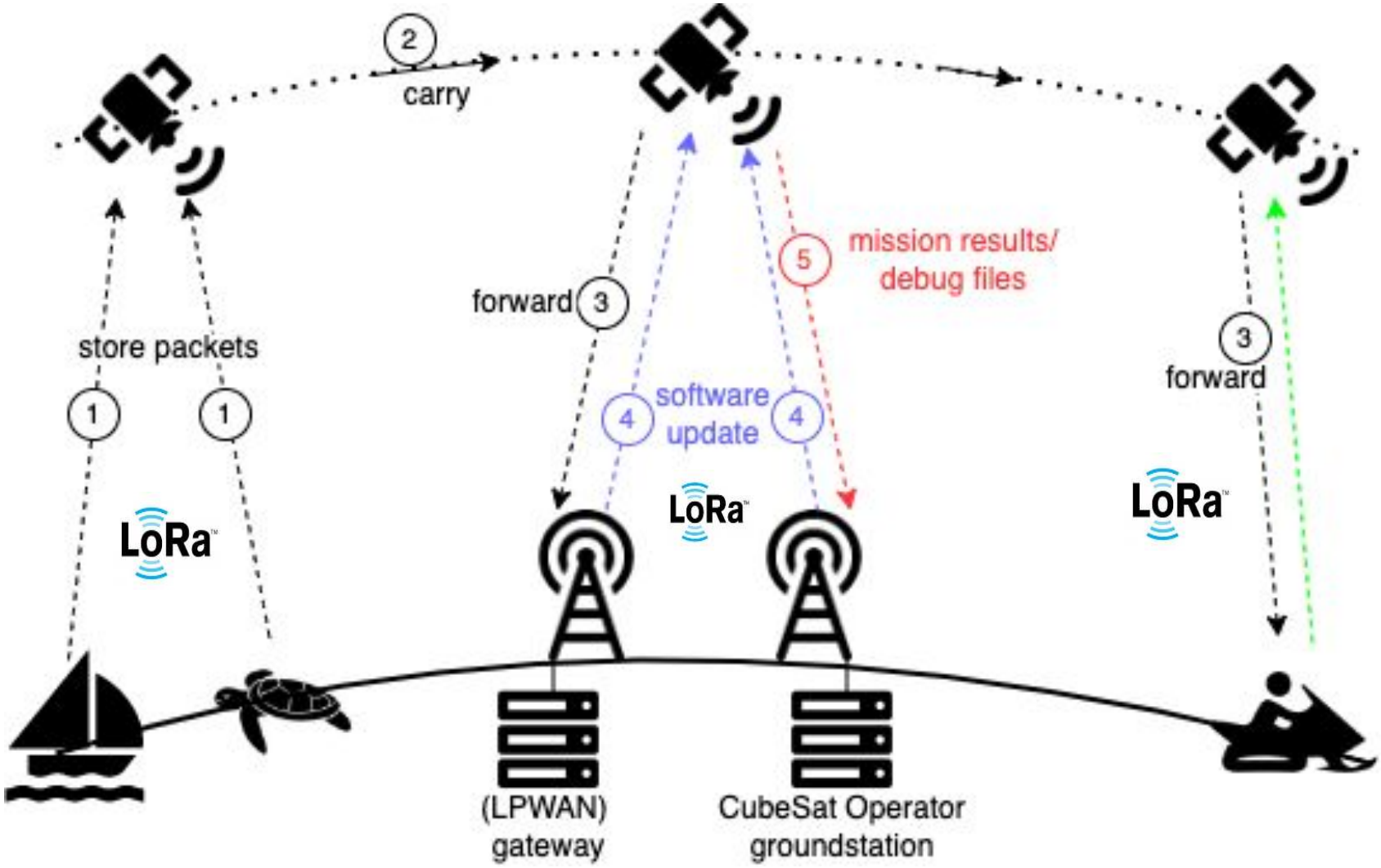


Emergency Warning Services (EWS) & Search and Rescue (SaR) alerts.



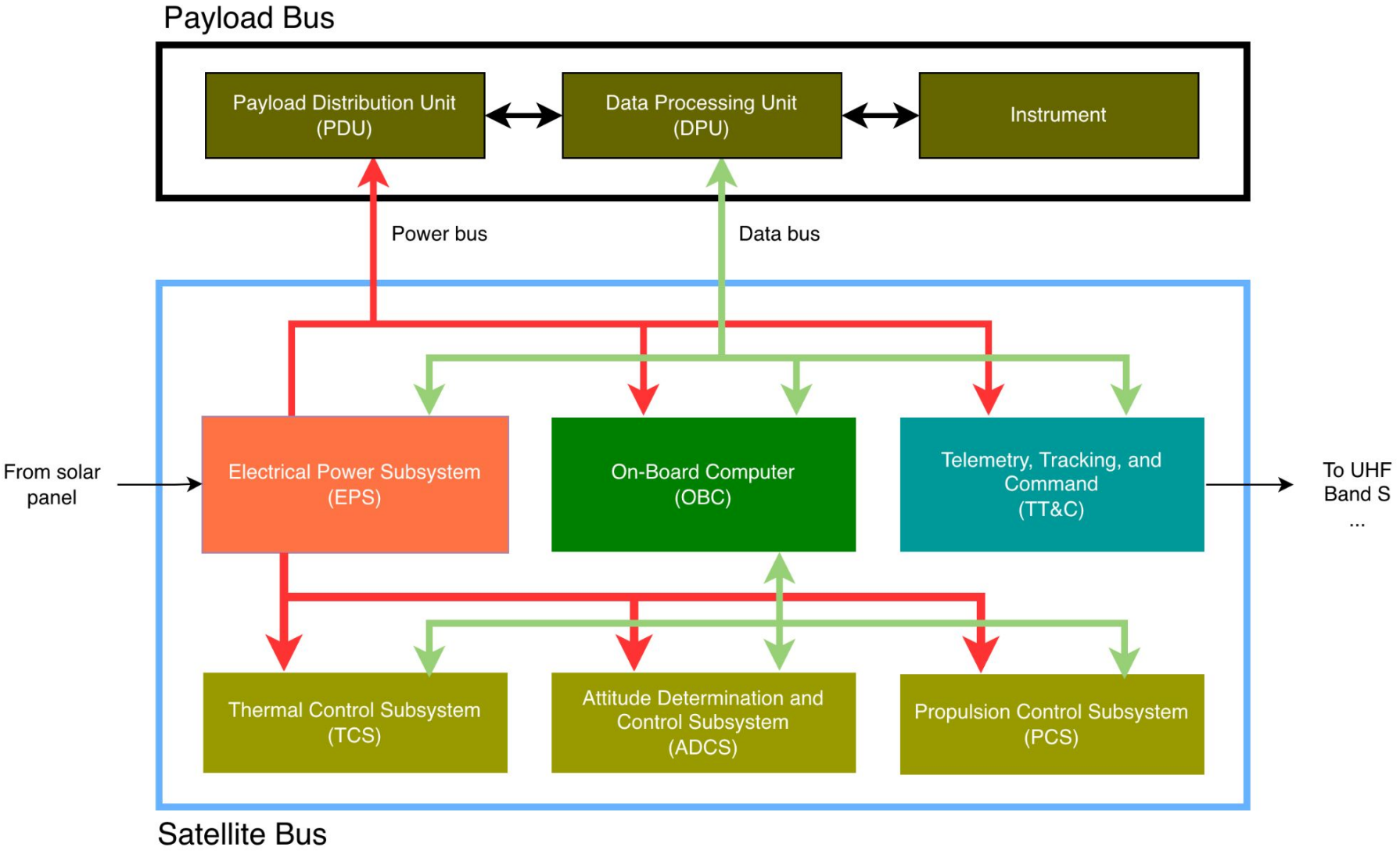
Positioning, Navigation, and Timing (PNT) & RF-ranging / localization experiments.

ThingSat Overview

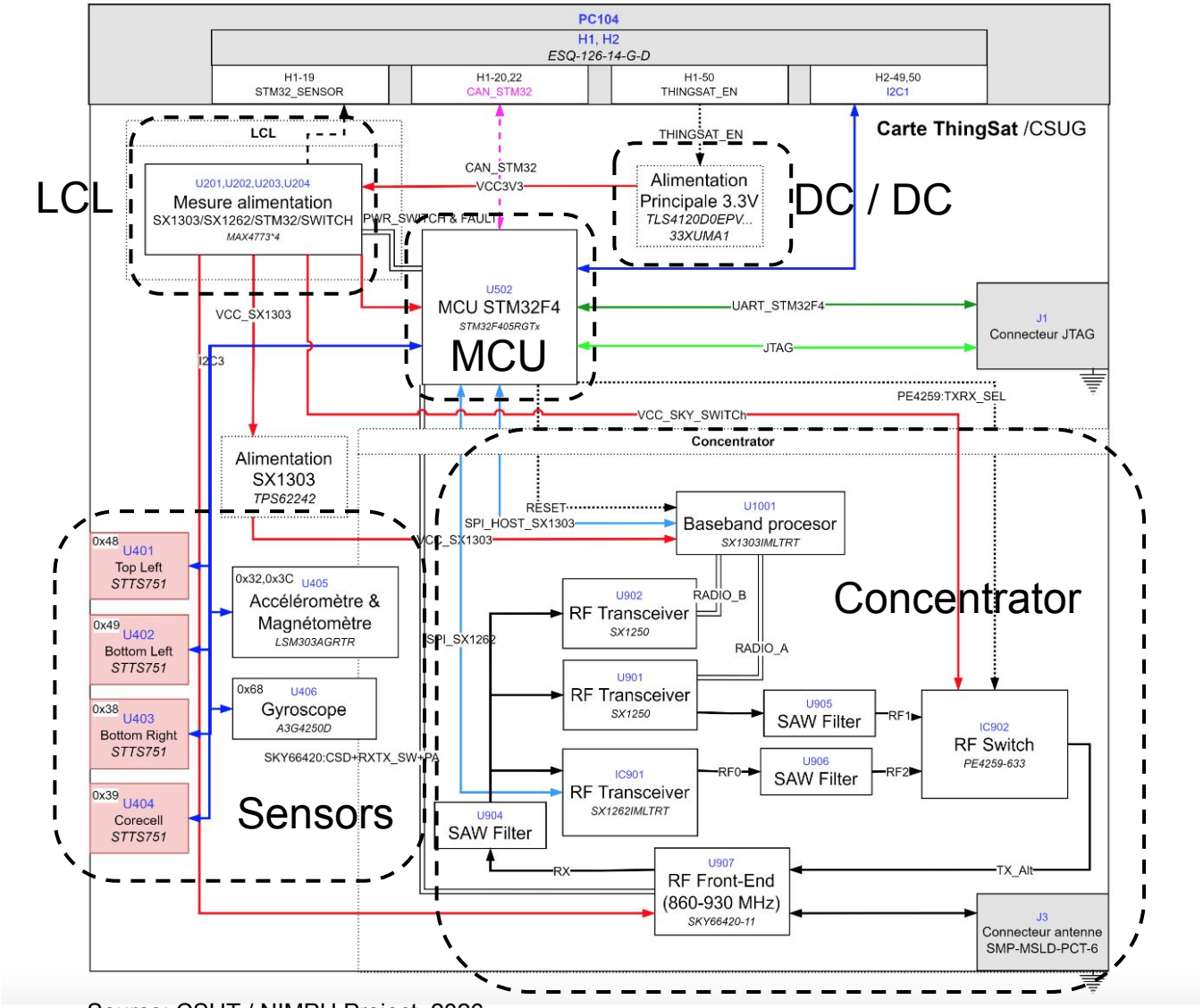


Thingsat LNS, Orange LNS…

Platform / Payload Bus Architecture

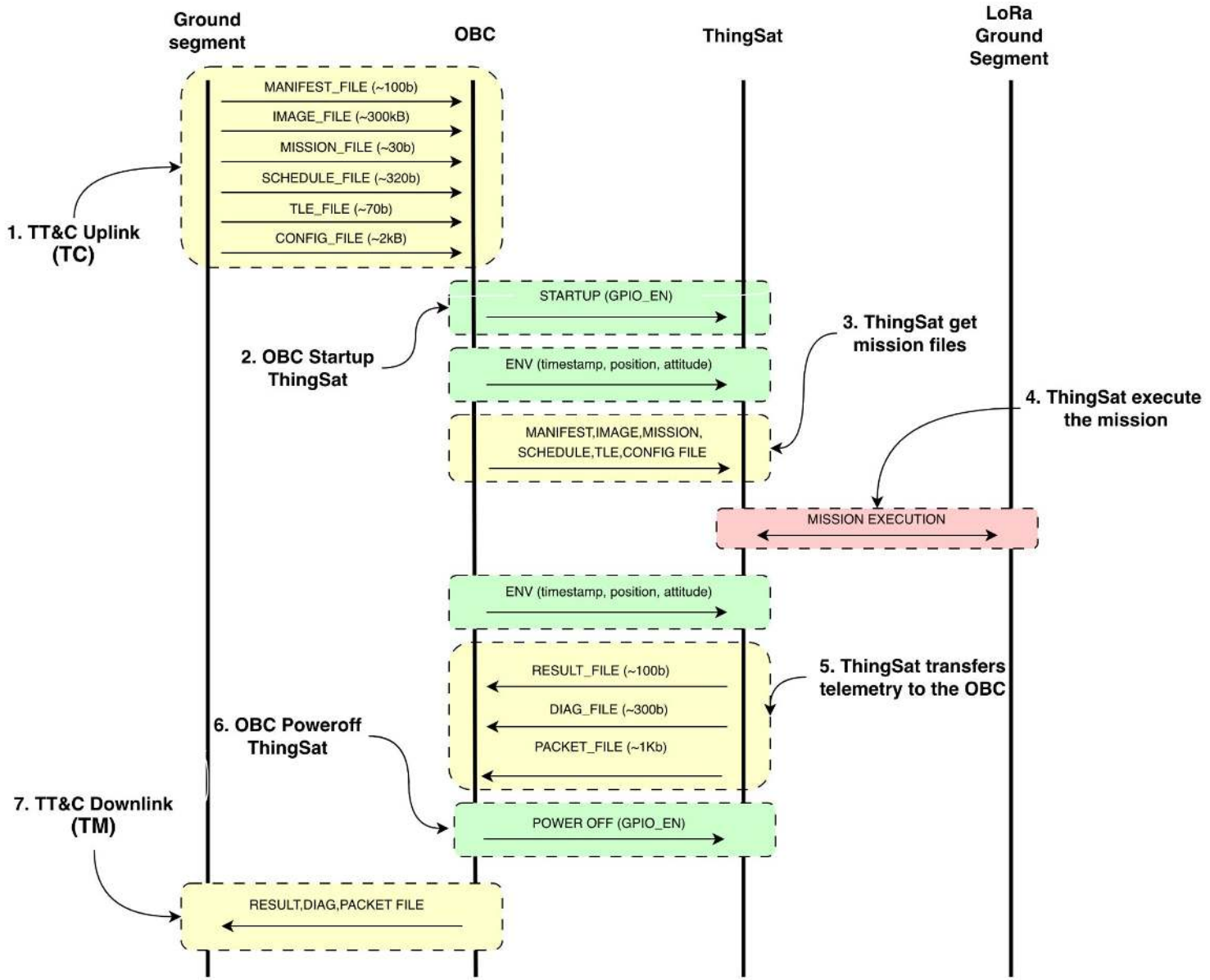


Hardware Architecture

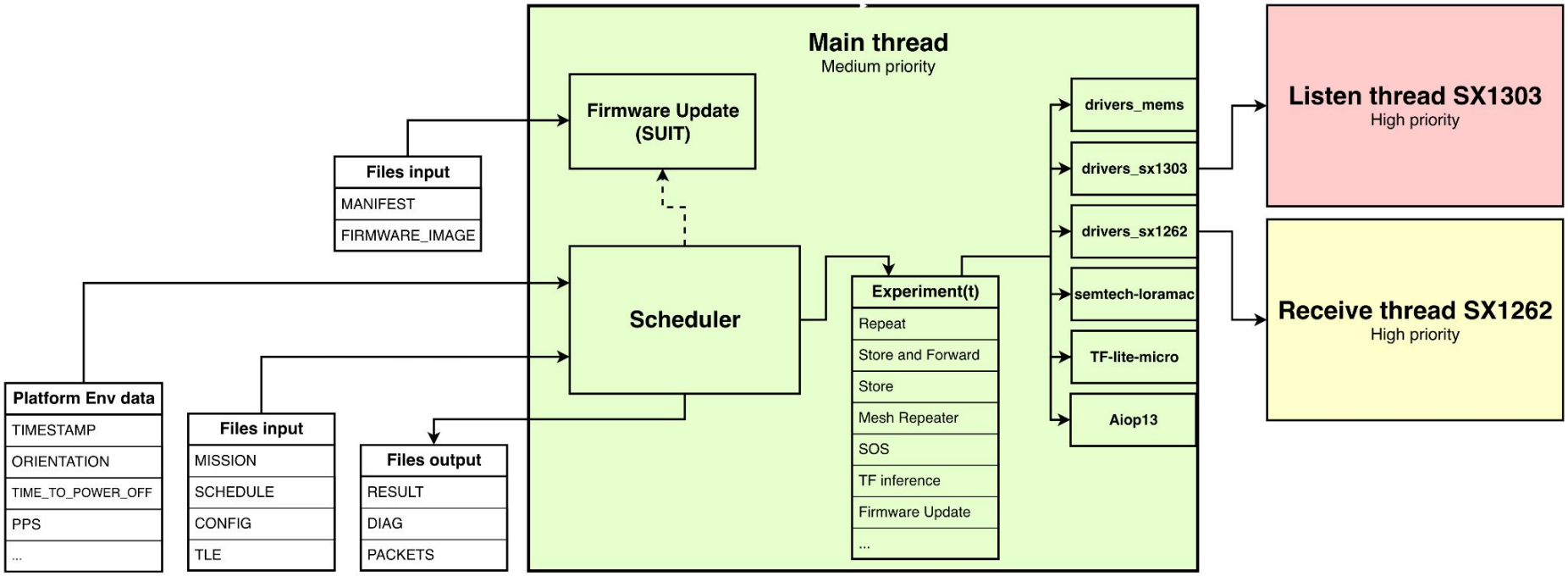


Source: CSUT / NIMPH Project, 2026

Data Exchange



Software Architecture



ThingSat Firmware development

Requirements

- Low power MCU STM32
- Open Source (Active community & INRIA leadership)
- Small footprint
- Multithreading
- Network drivers architecture (incl LoRaWAN)
- Firmware Update Over The Space (LibCSP/CAN, PB/RS485)

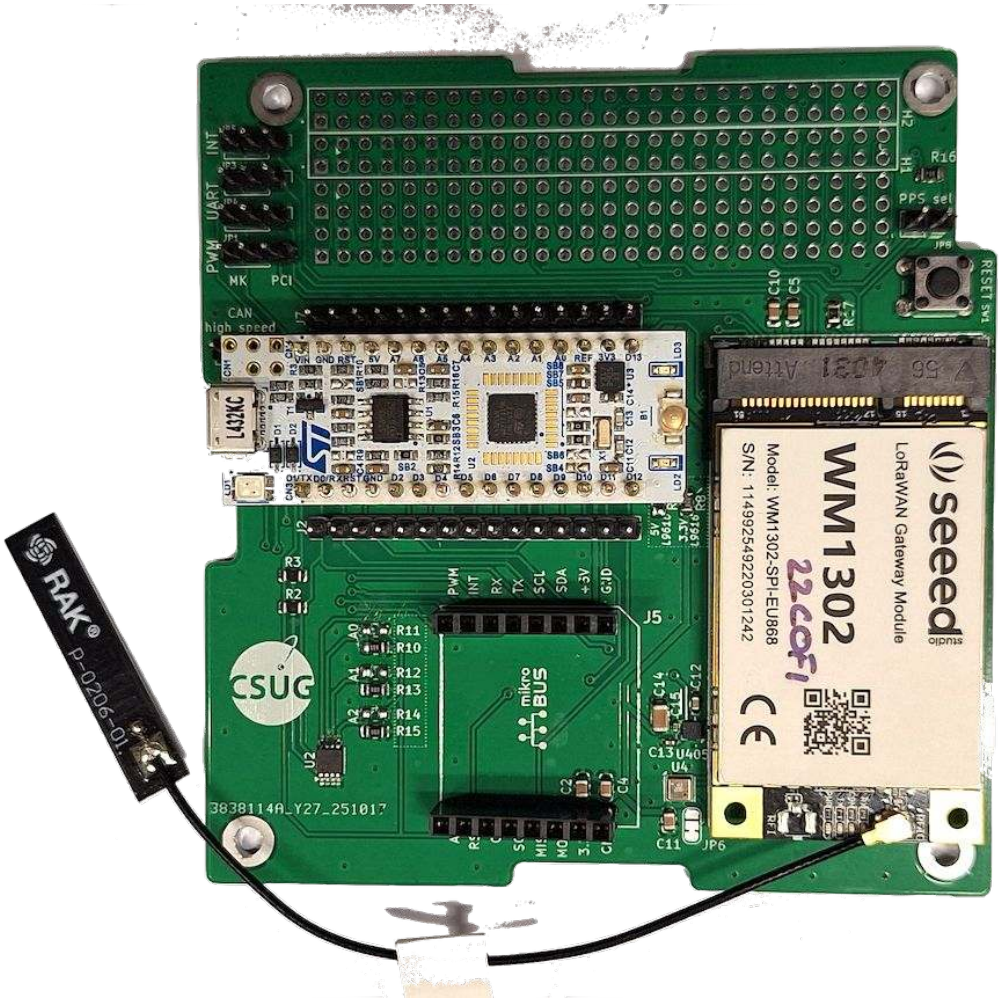
ThingSat firmware development (inherited from ThingSat @ Stork-1 and Orbiteo One)

- SX1303 (gateway) driver upgrading
- SX1262 driver upgrading (for LR-FHSS)
- semtech-loramac upgrading (for LR-FHSS)
- LoRa Mesh messages
- Protobuf over RS485 UP4 API (I2C slave soon)
- SUIT over Protobuf over RS485 UP4 API (I2C slave soon)
- Scenario engine
- TLE library (Orbital calc.) for blacklisting “sensible” earth areas
- MEMS drivers
- TF Lite Micro integration (with secure provisioning of TF models)

Pedagogical boards : Thingsat ProtoSEED

for teaching and for stratospheric tests

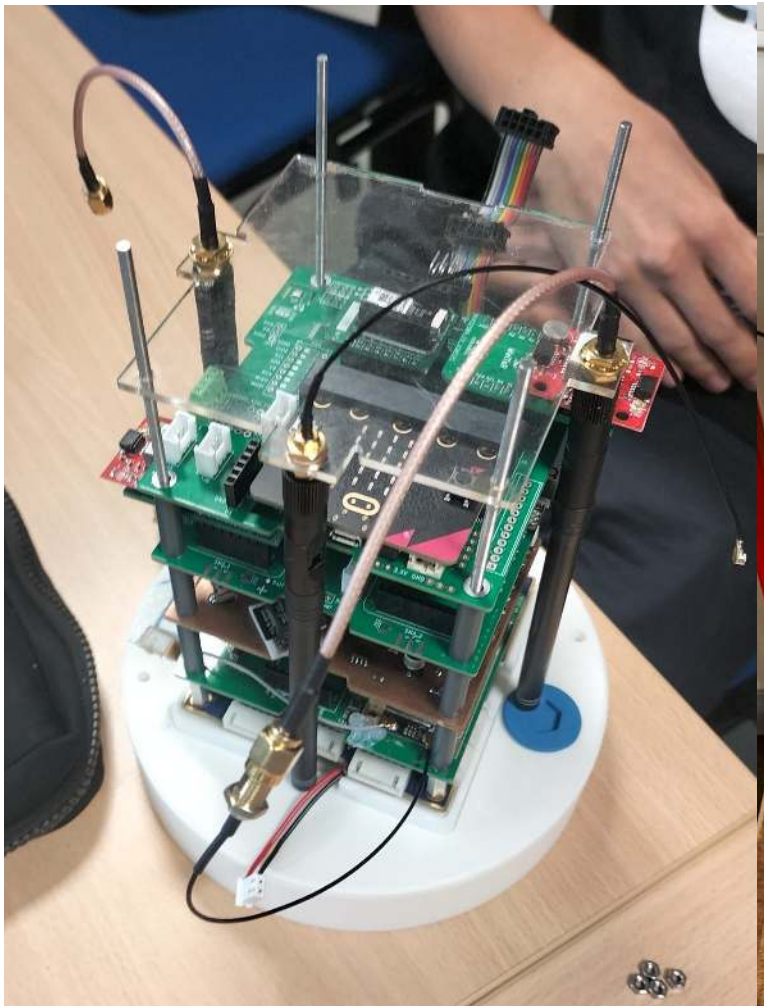
https://gricad-gitlab.univ-grenoble-alpes.fr/thingsat/seed/-/tree/main/seed_thingsat_protoseed?ref_type=heads



Stratospheric balloon tests (CNES Nanolab Academy)



https://gricad-gitlab.univ-grenoble-alpes.fr/thingsat/thingsat-training/-/blob/main/balloons.md?ref_type=heads





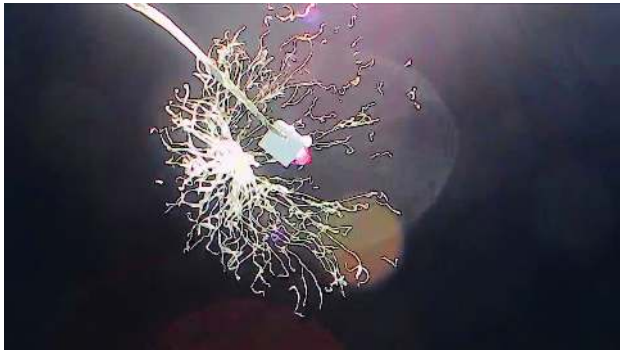
Stratospheric balloon tests (CNES Nanolab Academy)

Burst at 28000-32000 m









Thanks for your contribution!



Grenoble University Space Center (CSUG)

The “NewSpace” revolution (faster, cheaper): democratization of access to space, with the emergence of new private and academic players.

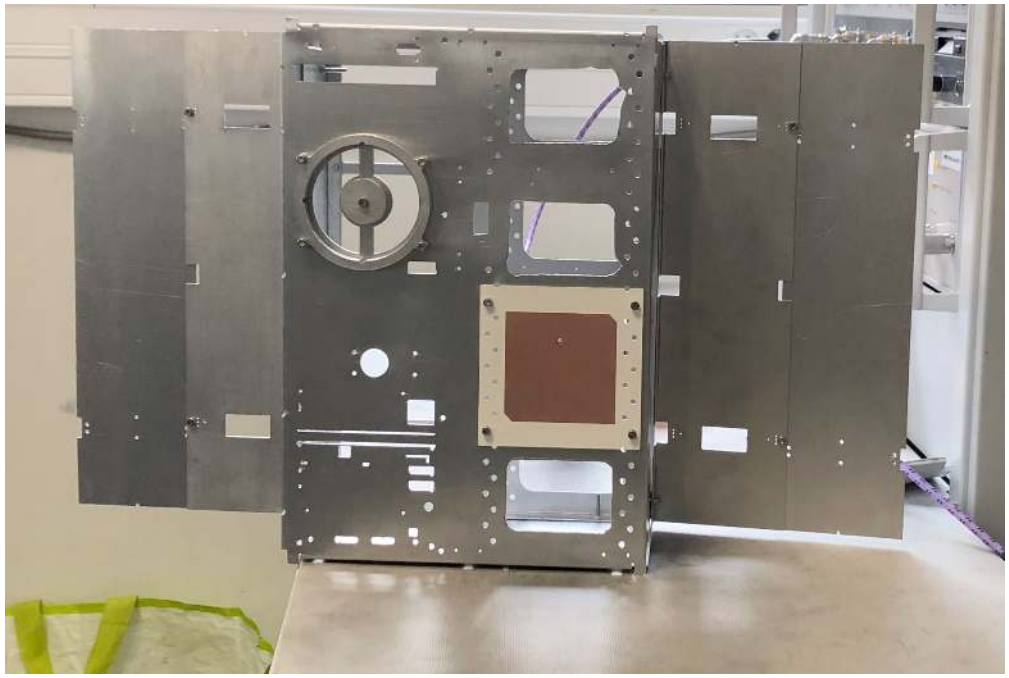
More than 5,000 jobs in the space sector in Isère, supported by a world-class electronics and digital technology ecosystem (hardware and software).

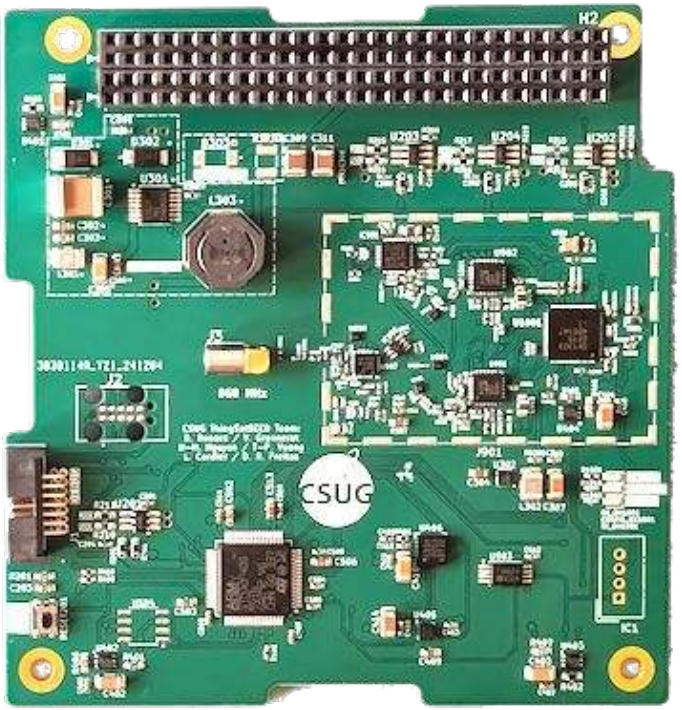
UGA: a university at the forefront of research and innovation.

CSUG

- Bringing together stakeholders from research, industry, and education by engaging them in innovative new-space projects
- Research and innovation projects led by researchers and/or initiated by companies
- **Students trained** through hands-on project-based learning

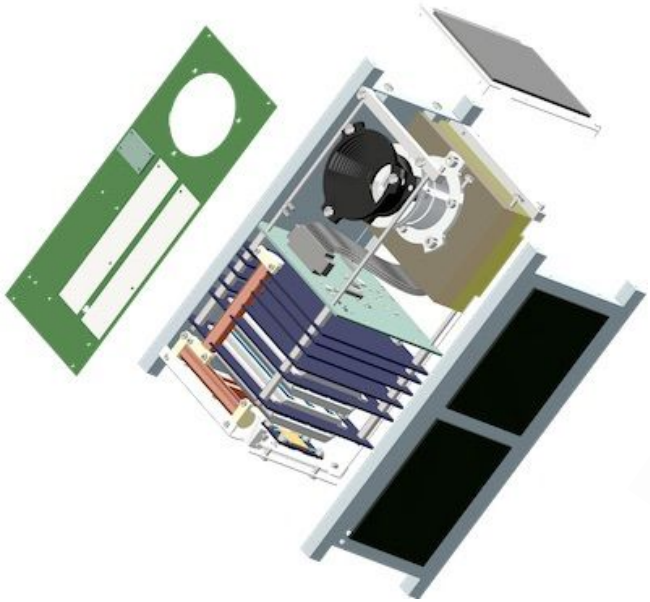
ThingSat payload

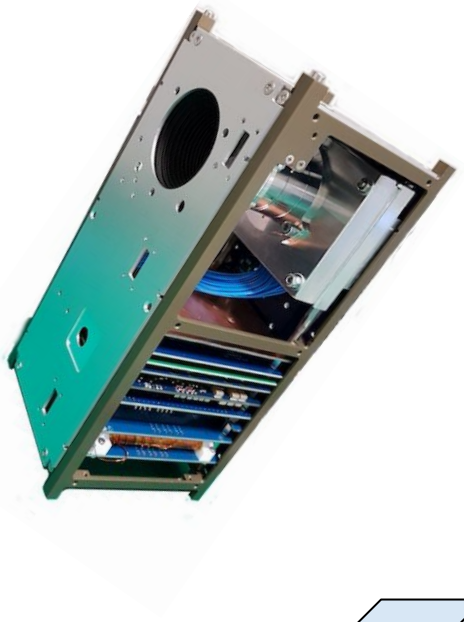


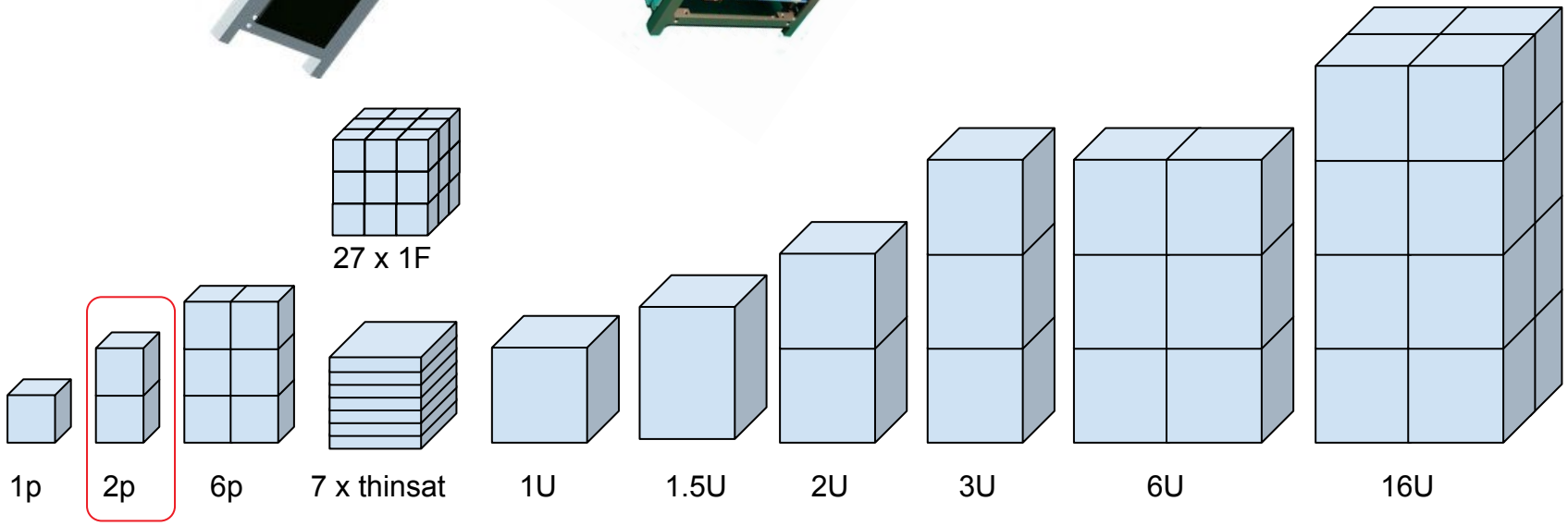


“New space”: space for the mass

cubesat : Agile and “affortable” LEO satellite



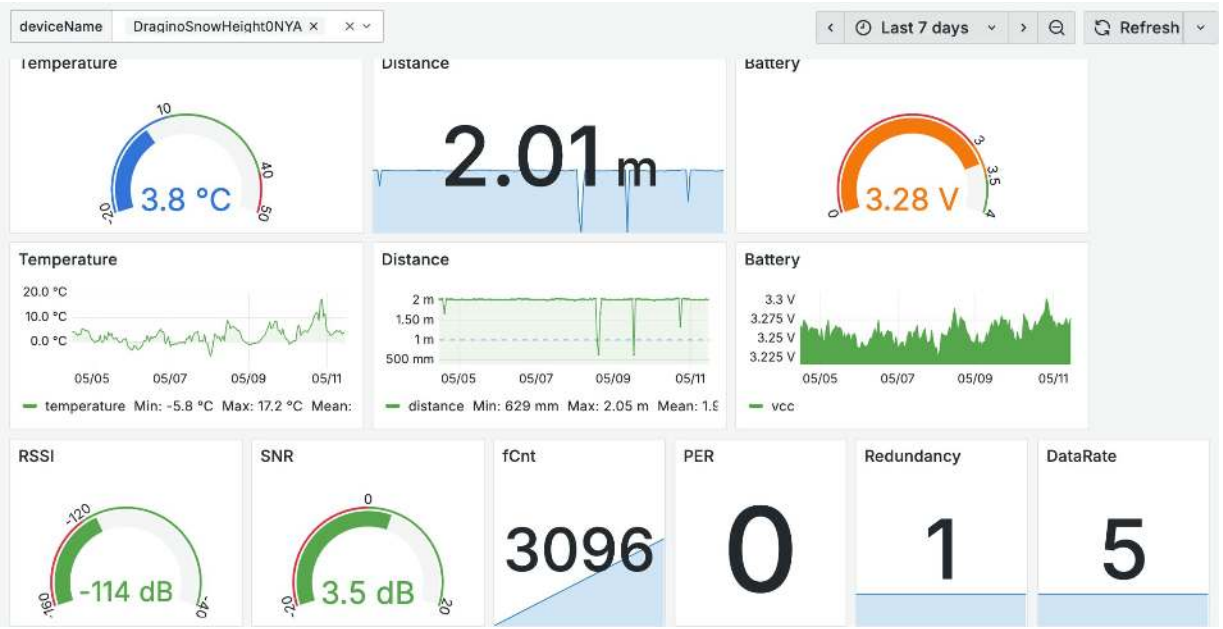




Extreme IoT

78.905162,12.117587



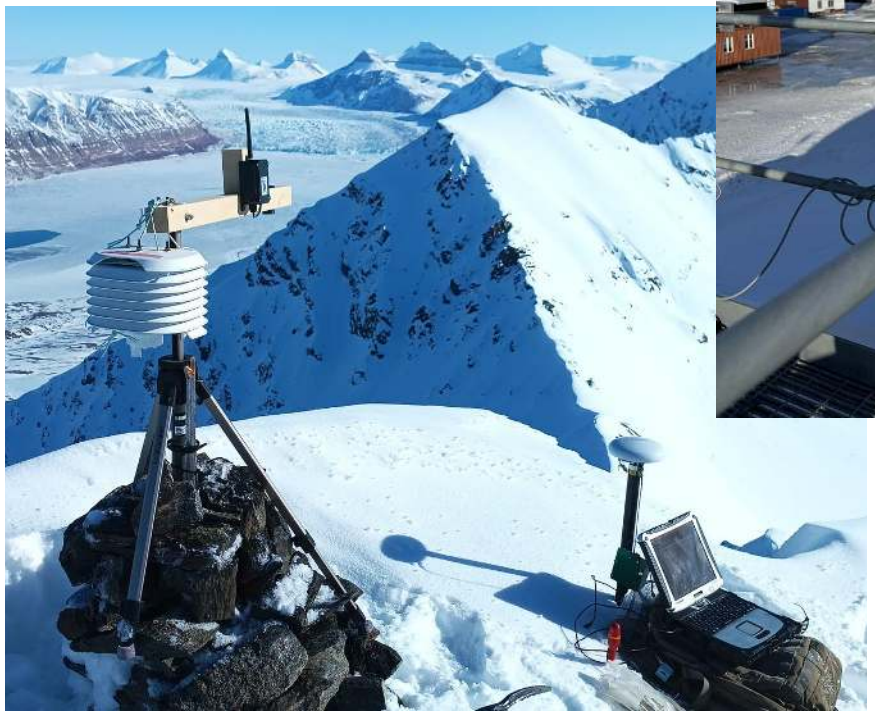




Extreme IoT networking for environmental sciences (hydrology, glaciology, natural risks …)

- Alps, Svalbard,
- Antartica (2027)





JM Friedt @ Corbel, Svalbard



https://www.ige-grenoble.fr/Toujours-plus-haut-Le-suivi-en-temps-reel-de-la-neige-en-haute-altitude

Hydrology

Water level sensor network for Angkor water channels

joint project with students NPIC🇰🇭/Polytech🇫🇷 (2023)





Rural community networks 🇨🇲🇸🇳🇮🇳

🌴🐘🐆🦍







I2HM (Internet of things and artificial Intelligent for Health monitoring) https://i2hm.github.io/

Application : Microclimate sensors for Malaria surveillance

- Malaria (WHO, 2021)
  - **247 million cases** worldwide
  - **619,000 deaths : 25%** attributed to **environmental factors**
- Surveillance (IoT)
  - low cost and low tech LoRaWAN weather stations for collecting environmental data
- Prediction/prevention (IA ML)
  - Machine (Deep) Learning for predicting and alerting in case of Malaria epidemic hotspots
- Sites (covered by terrestial LoRaWAN gateways or sat)
  - Yaoundé (Cameroun), Niamey (Niger)
  - **Remote areas of African countries are badly covered by terrestrial networks**







UGA Université Grenoble Alpes

MIAI Grenoble Alpes

https://en.wikipedia.org/wiki/Malaria

Disaster networks

Projet VERCORS (Région AURA)

SDIS38 - OneTreck - LIG

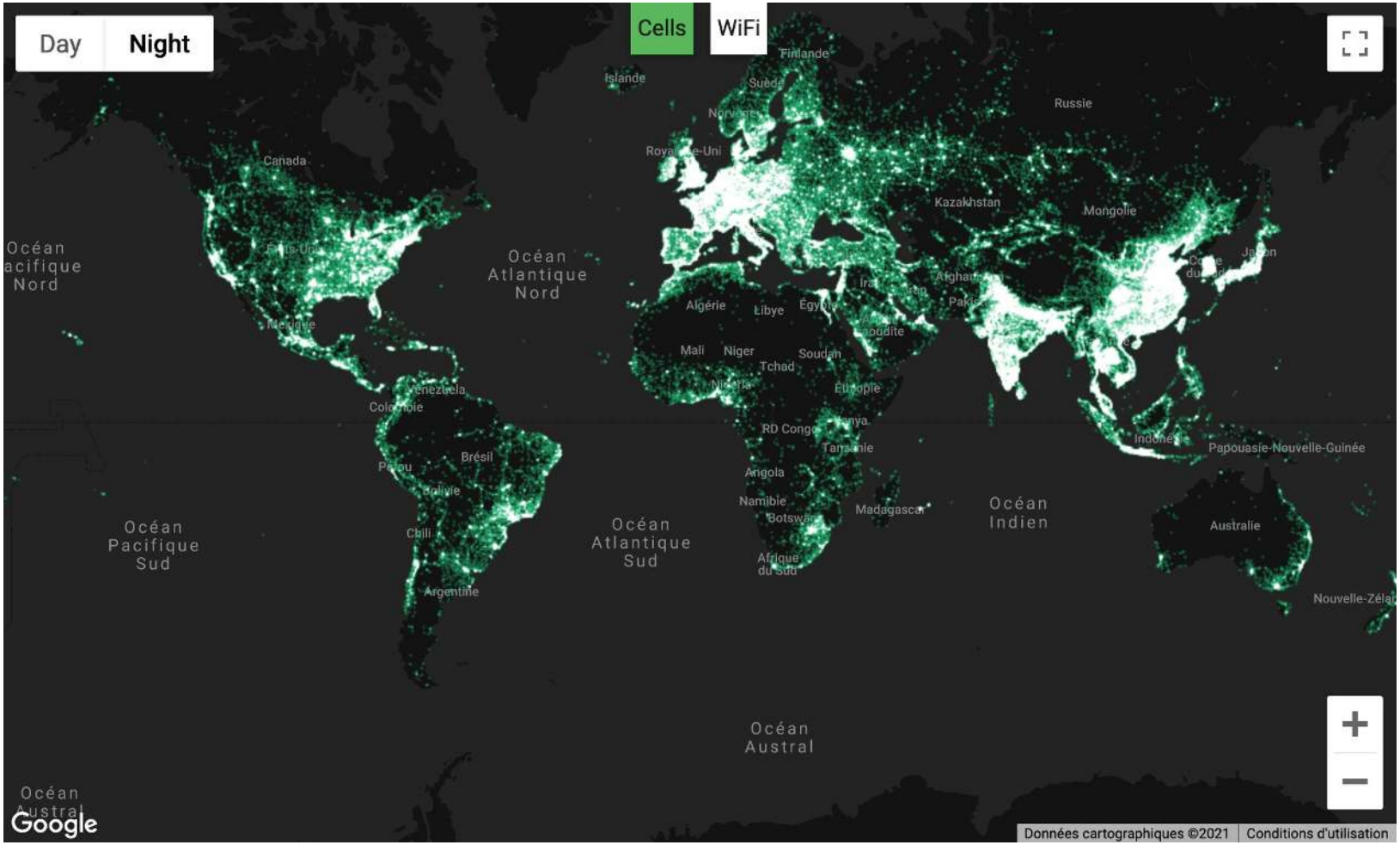




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crédit Seeedstudio https://www.seeedstudio.com/Mission-Pack.html

Lot of “white” zones on Earth

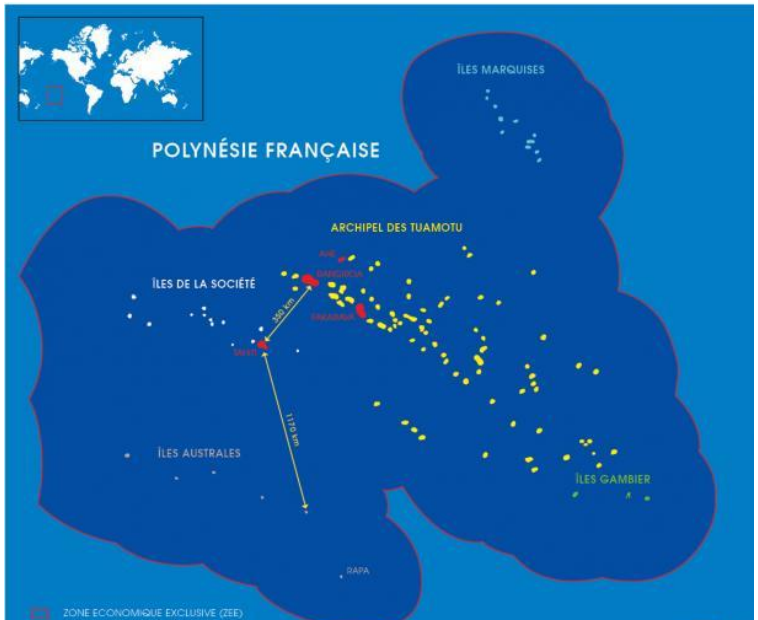


Couverture cellulaire et wifi http://unwiredlabs.com/coverage

Internet of Isolated Things

IoT networks cover only a few part of the Earth

Unpopulated areas (Deserts, oceans, pole regions, tropical forests) are “not” connected to the global web



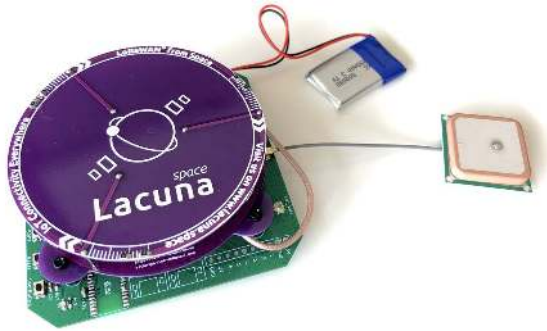


Low Power Global Area Networks (LPGAN) or SatIoT

- Satellite constellation (fat or nano) forwarding IoT messages from/to isolated endpoints
- LPGAN operators (*LoRaWAN, NB-IoT, Mioty …*)
  - LEO: Lacuna Space, Astrocast, Kineis, …
  - GEO: ~~Echostar Mobile~~, …







credits: Lacuna space, Kineis

What is Direct-to-Satellite IoT ?

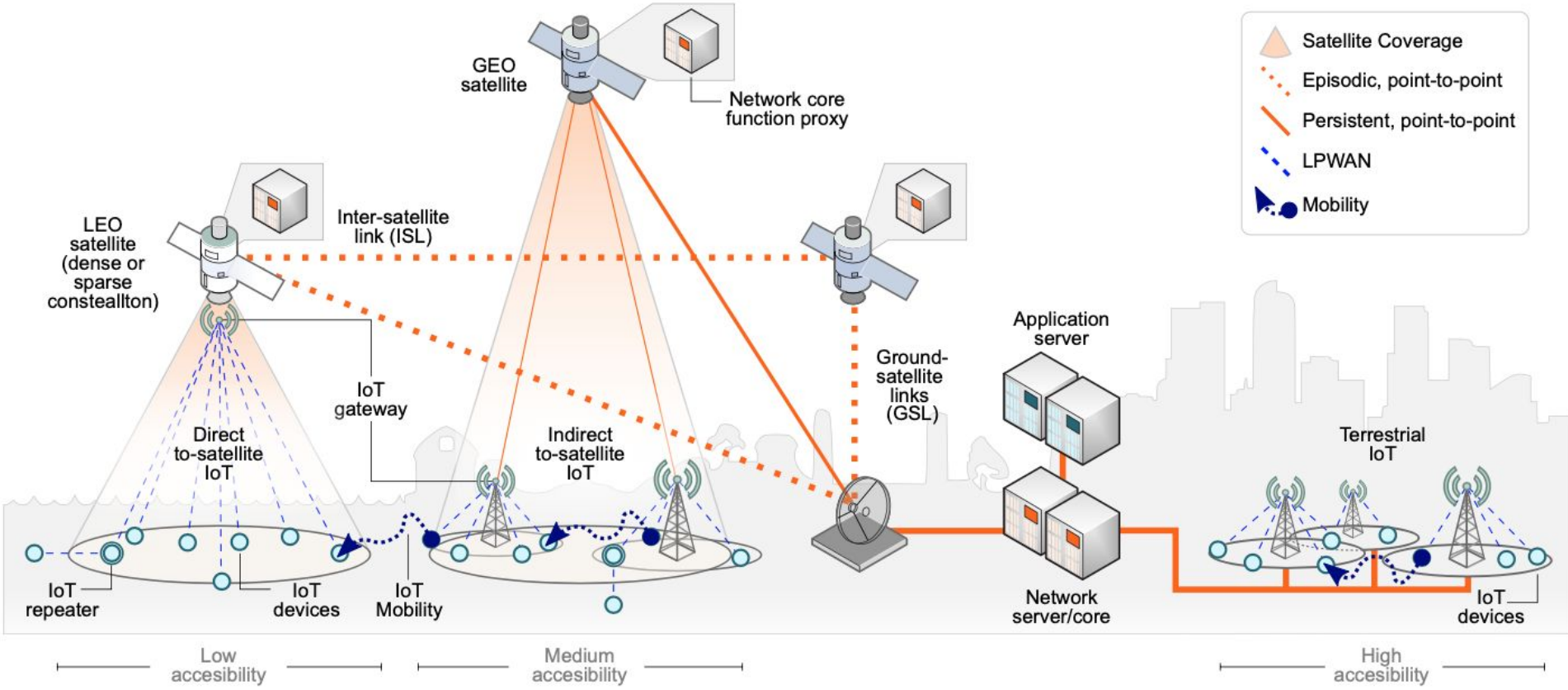
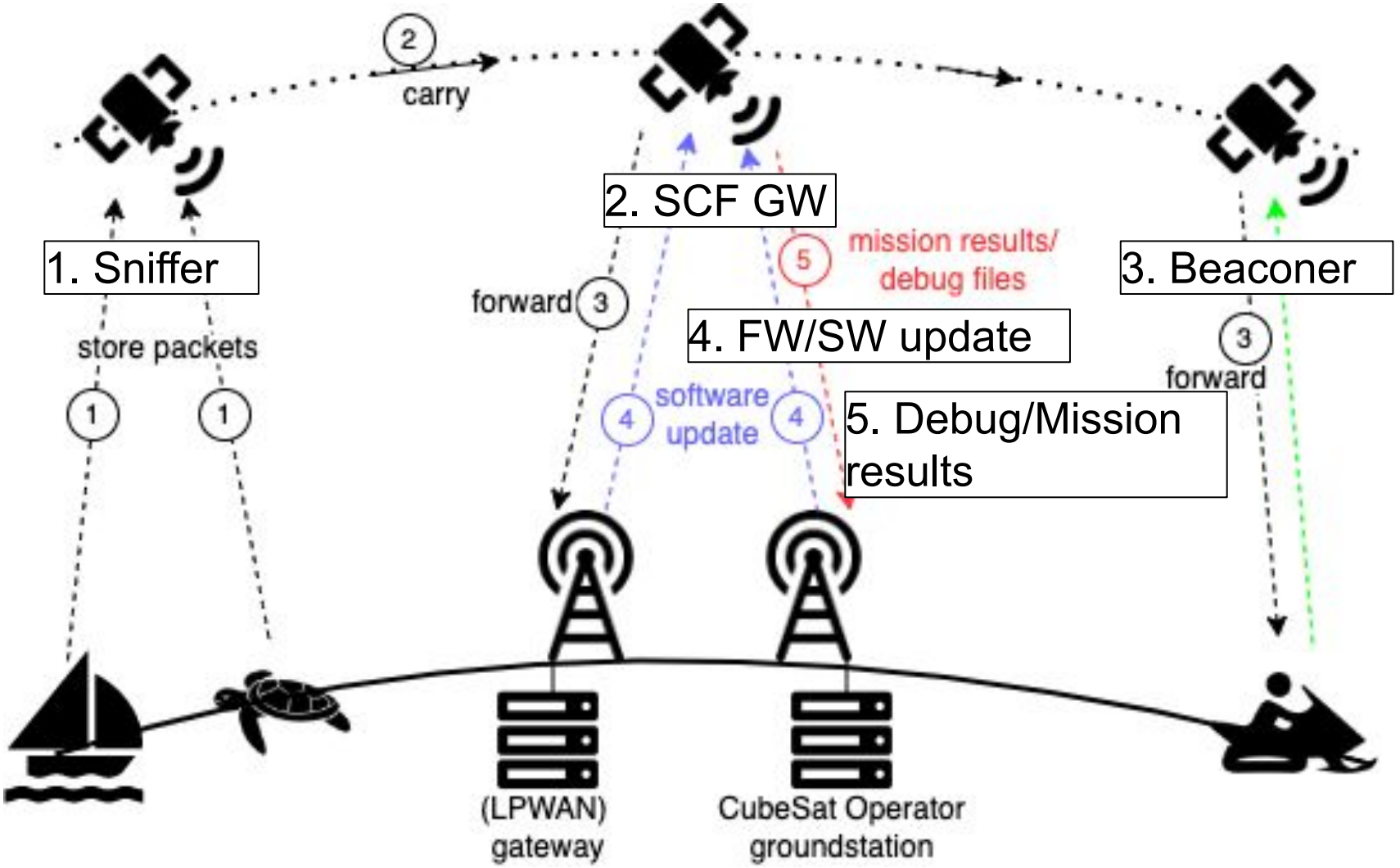


Figure from [Fraire et Al, « Space-Terrestrial Integrated Internet of Things: Challenges and Opportunities ». IEEE Communications Magazine 60, nº 12 (décembre 2022)]

525-km LEO LoRa base station



HAPS

High Altitude Pseudo Satellites | High Altitude Permanent Systems

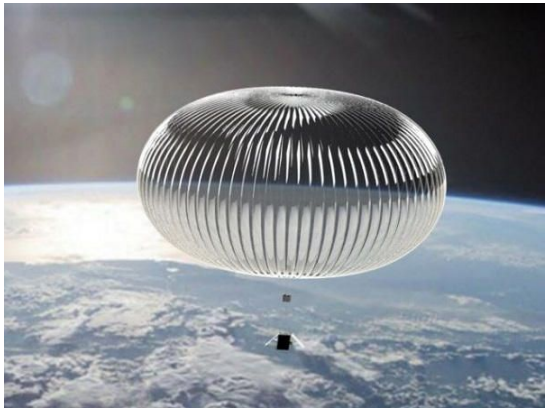
UAV heavier or lighter than air

@ 20,000-25,000 m altitude (-56 °C) for several weeks

earth observation

communication: white zones, disaster networks, tactical networks …



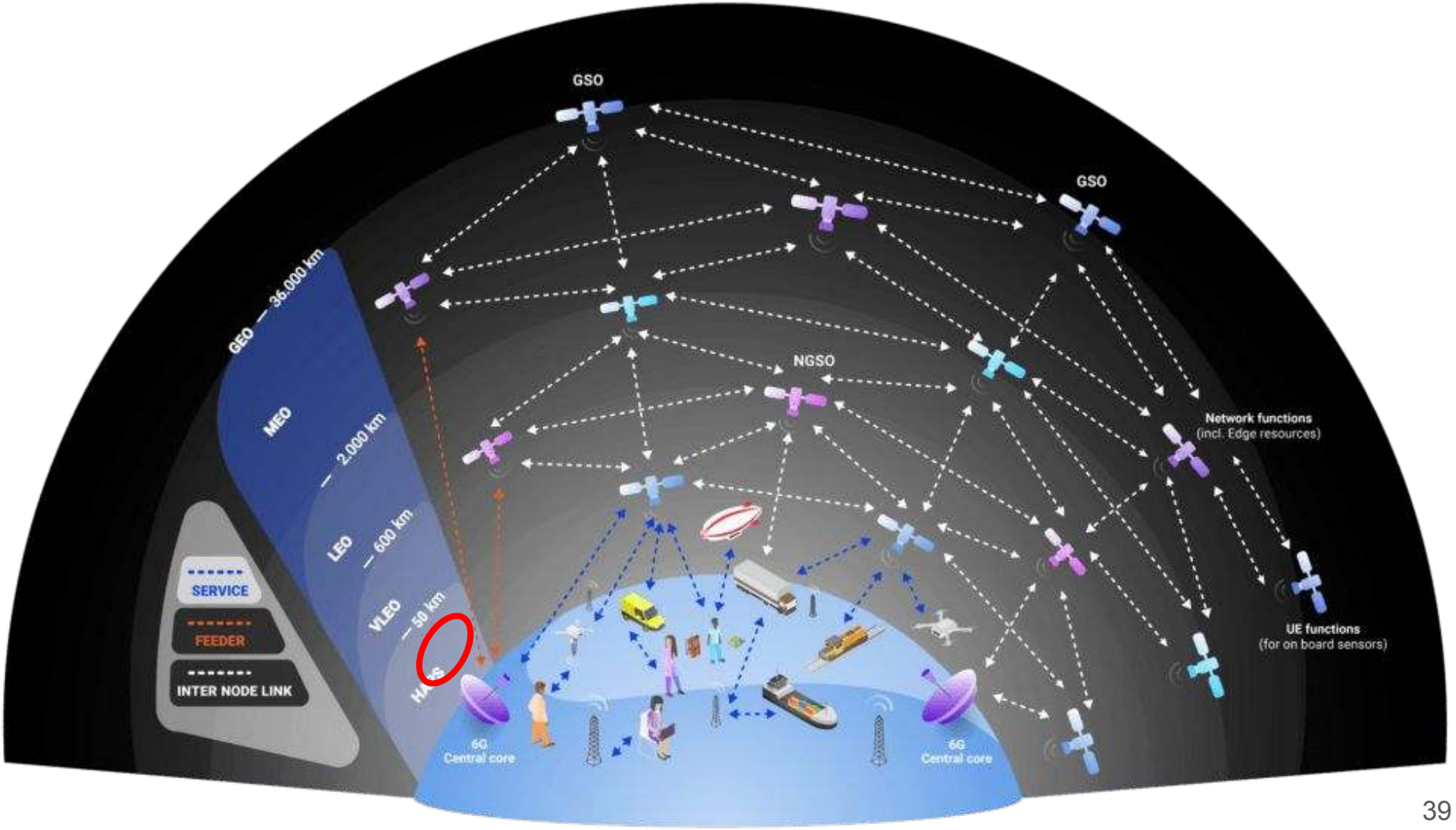






https://www.annales.org/enjeux-numeriques/2024/resumes/mars/04-en-resum-FR-AN-mars-2024.html#04FR

6G Terrestrial and Non-Terrestrial Networks
Fatsat, Nanosat, HAPS are part of 6G infrastructures



AMI Compétences et Métiers d'Avenir

cometes

1+5 SatIoT pedagogical constellation

Affortable SatCom ground stations
all over the world



ROADMAP 2026-2032 | Prévision de la disponibilité de la constellation - 2026-2031

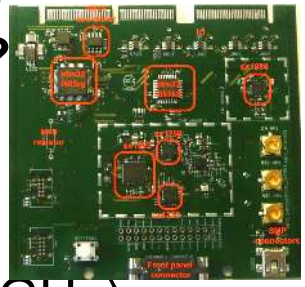
Durée de vie des cubesats : 2-3 ans en moyenne

Organisation	Satellite	Couleur hex	Début	Fin	2026	2027	2028	2029	2030	2031	2032	2033
CSUG	SatRev	#3DC9A0	2026	2028	✓	✓	✓					
CSUT	NIMPH	#E08C2A	2027	2029		✓	✓	✓				
CSU NAASC	NANONAASC	#9B59B6	2027	2029		✓	✓	✓				
CSU UCA	NiceCube	#4A90D9	2028	2030			✓	✓	✓			
CSUG	G3Sat	#1A6B4A	2029	2031				✓	✓	✓		
CSUM	DESDEMONE	#C0392B	2029	2031				✓	✓	✓		

Sats actifs par année	2026	2027	2028	2029	2030	2031	2032	2033
Nombre de satellites actifs	1	3	4	5	3	2	0	0

Thingsat Missions (i)

Mission 1 : STORK-1 (NORAD 51087 → *no longer on orbit*)
Launch SpaceX: January 2022 (init. Mai 2021)
cubesat comm lost : Dec 2022 (*Solar flare ?*)
¼U + antenna (< 100cm2)
STM32F405RG (192KB RAM + 1024KB FlashRAM)
MEMS + CAN Bus
LoRa CSS : SX1302 (868MHz) + SX1280 (2.4GHz)
RIOT OS





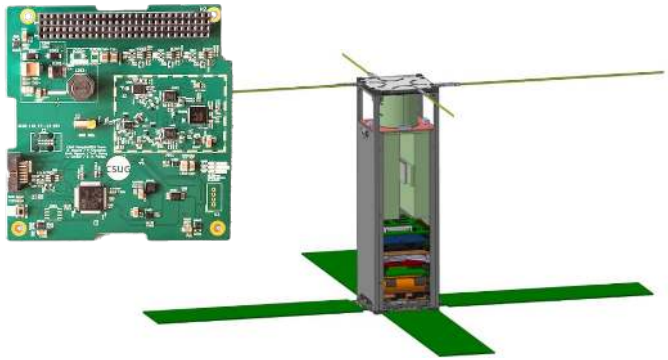
Mission 2 : Orbiteo One (6U)
¼U + antenne (< 100cm2)
STM32F405RG (192KB RAM + 1024KB FlashRAM + 128
MEMS + RS485
LoRa CSS, LR-FHSS : SX1303 (868MHz) + SX1262
Launch SpaceX: ~~Q3 2024~~ **October 2026**
RIOT OS





Thingsat Missions (ii)

Mission 3 : Nimph CSUT - CNES Nanolab Academ
EM ready - FM in production
Launch: 2027
¼U + antenna (< 100cm2)
STM32F405RG (192KB RAM + 1024KB FlashRAM + 1024KB EEPROM)
PC104 with I2C
Modulations: LoRa CSS, LR-FHSS : SX1303 (868MHz)
RIOT OS



4-5 Mission X : COMETES (*french national funding for new space teaching*)
¼U + antenne (< 100cm2)
Launch: 2027-2030
STM32F405RG (192KB RAM + 1024KB FlashRAM + 1024KB EEPROM)
or STM32N657 (with AI accelerator)
PC104 with RS485, CAN, I2C
Modulations: LoRa CSS, LR-FHSS : SX1303 (868MHz + 433MHz + SBand + 2G4)
RIOT OS or Ariel OS ?

Thingsat PC104 (Nimph, CNES SEED)

Footprint: ¼ U (~60 grammes sans header PC104)



Hardware (customizable on PC104 pinout)

- STM32F405RG ()
- SX1303+2xSX1250 430 MHz or 868 MHz
- *LR1120 (SBand+2.4GHz+GPS)*
- MEMS (temp x4, acc, gyro, mag)
- *CAN Base, RS485, RS422, UART*, *USB*, I2C Slave, ***PPS (fine timestamping))***
- Power supply: regulated 3V3. **unregulated VBAT in option**

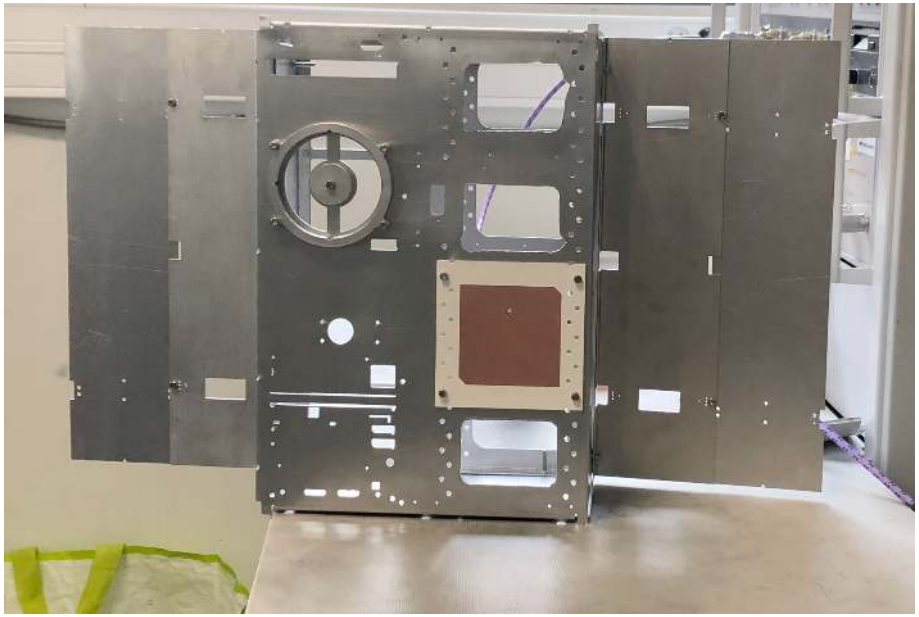
Software

- RIOT-OS
- PUS, AT modem, gRPC, *LibCSP (CAN) option*
- *RadioLib for LoRa Mesh*

Custom antenna (case of OrbiteoOne)

- Gain: 3.34 dBi
- Half-power beamwidth (-3 dB au niveau max) ~ 70 deg Polarisation
- Circulaire: oui
- Bande: 867.5 MHz - 869.525 MHz: oui

ThingSat custom antenna for Orbiteo One (868 MHz)



+ Gain: 3.34 dBi

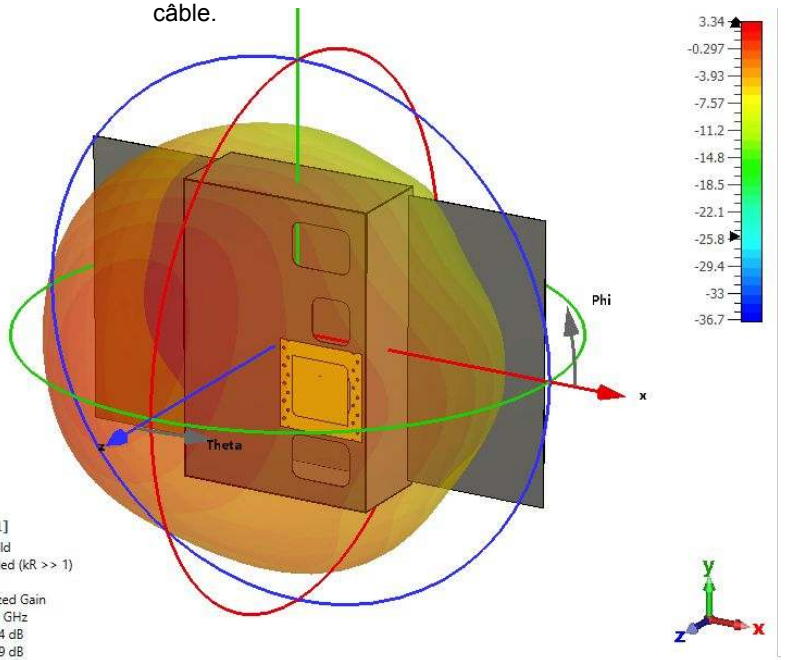
+ Half-power beamwidth (-3 dB au niveau max) ~ 70 deg Polarisation

+ circulaire: oui

+ Bande: 867.5 MHz - 869.525 MHz: oui

+ Dimension: 100mm x 100 mm x 1.524 mm.

+ Poids: ~38 g (diélectrique + cuivre) sans connecteur, sans câble.



farfield (f=0.868) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Realized Gain
Frequency	0.868 GHz
Rad. Effic.	-3.874 dB
Tot. Effic.	-3.959 dB
Rlzd. Gain	3.339 dBi

CubAClock PC104 (COMETES)

Goal

Low-Power and Secure PNT (Positioning, Navigation, Timing)

Low-Power and Secure Ranging (Sat2Sat)

Footprint: ¼ U

Hardware (customizable on PC104 pinout)

- STM32F405RG
- SX1303+2xSX1250 430 MHz or 868 MHz
- MEMS (temp x4, acc, gyro, mag)
- *Chip Scale Atomic Clock (Microchip, Safran Syrlinks)*
- ***Engineering Model Ready***



