

Standard Standalone Satellite-aided Internet connectivity

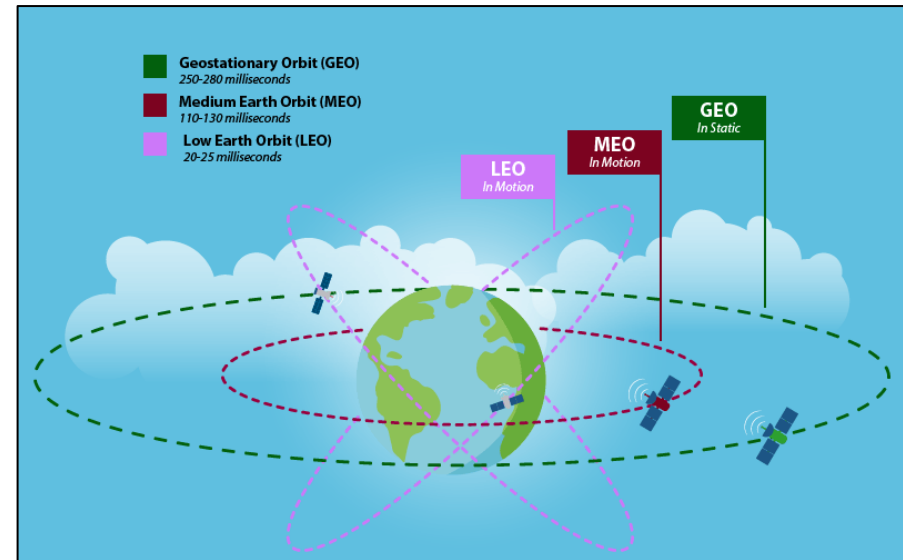
Nicola Accettura

NTN Days 2026



Why Satellite-aided?

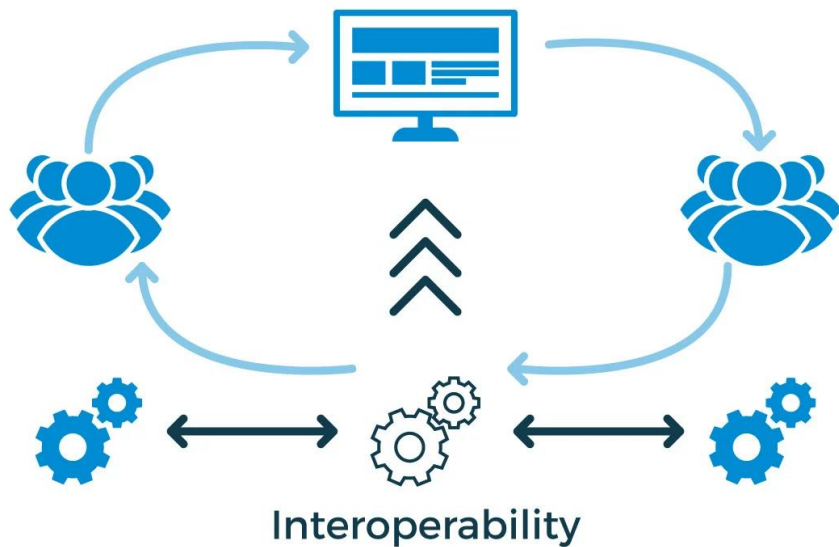
Limits of terrestrial networks



Low Earth Orbit (LEO)

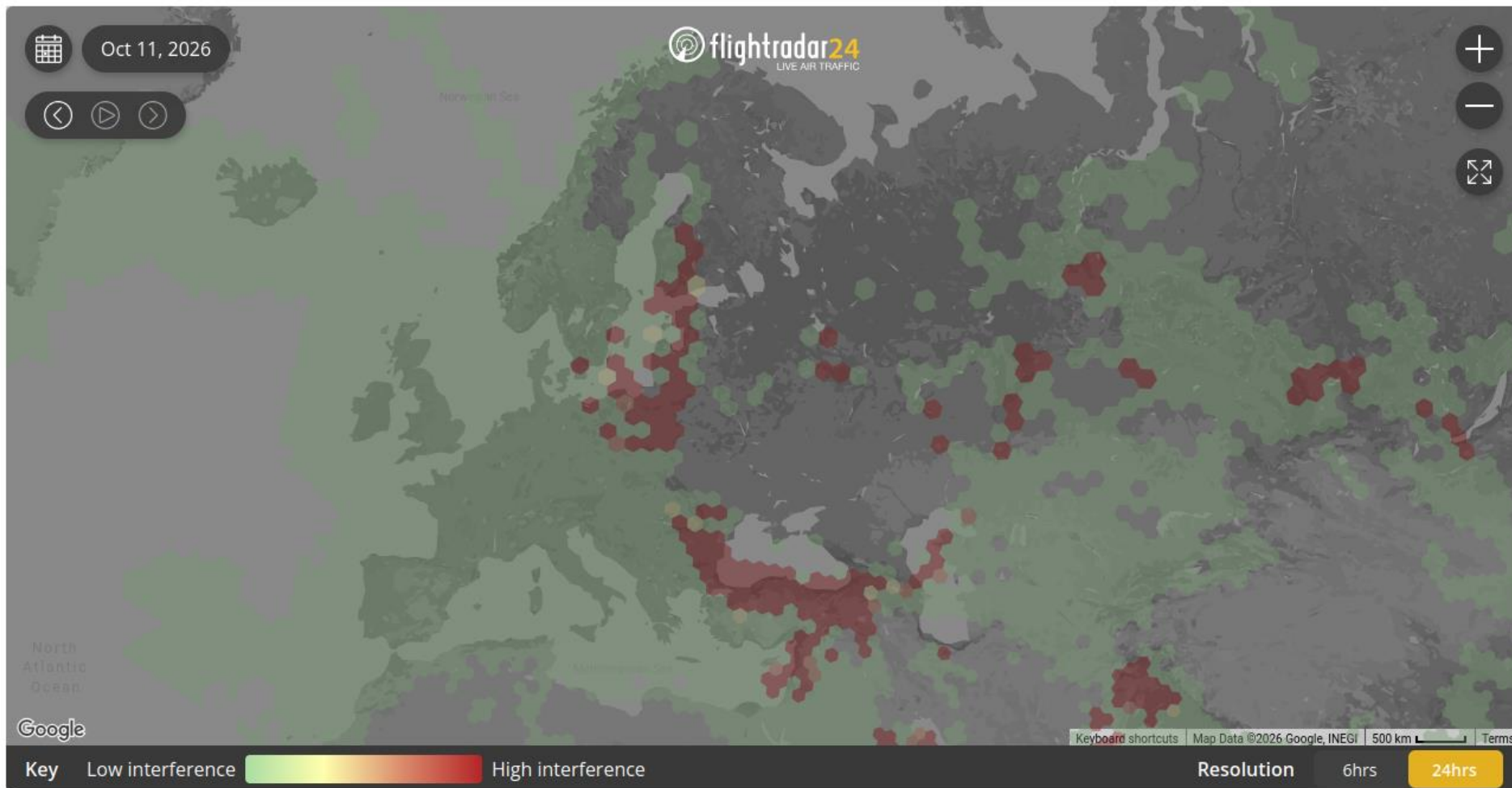
- 2 - 5 ms propagation delay
- Small-sized, low cost, low power CubeSat

Why Standard?

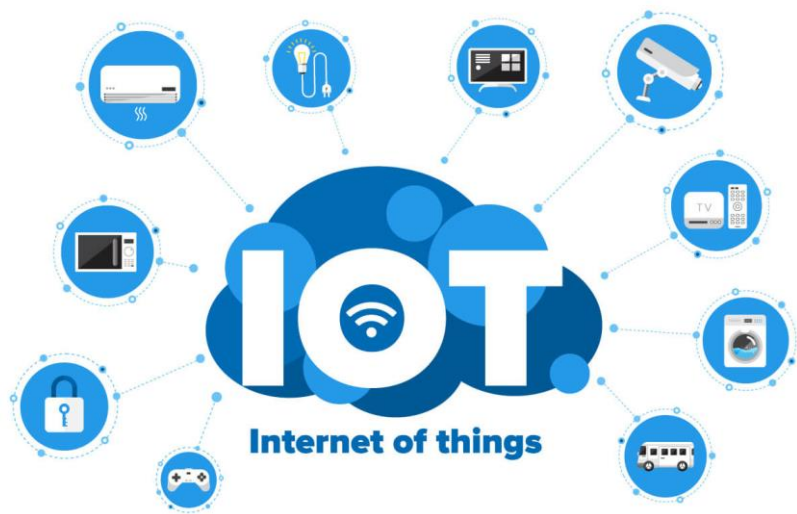


Why Standalone?

GPS jamming map



Internet of Things brought by LEO satellites

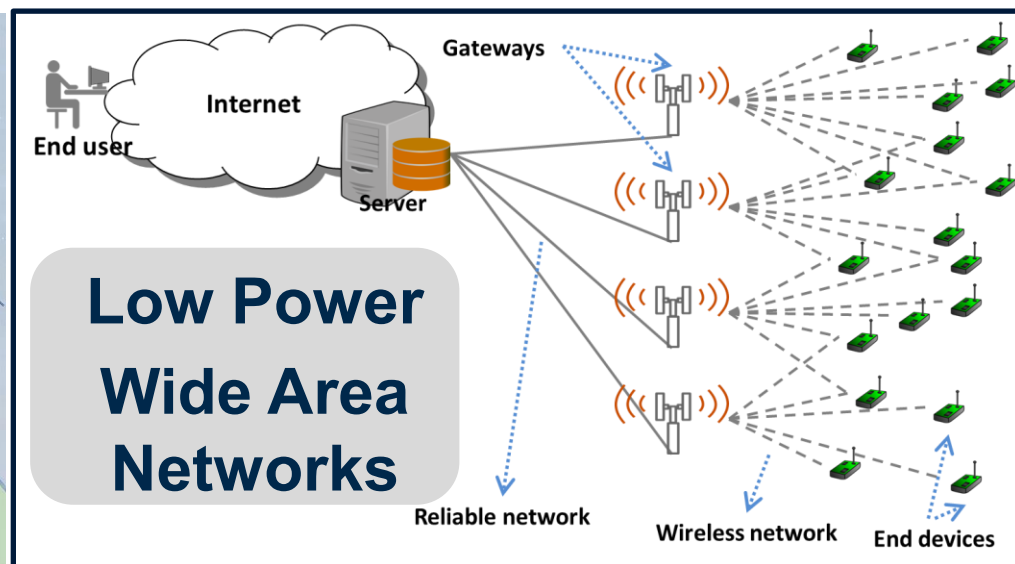
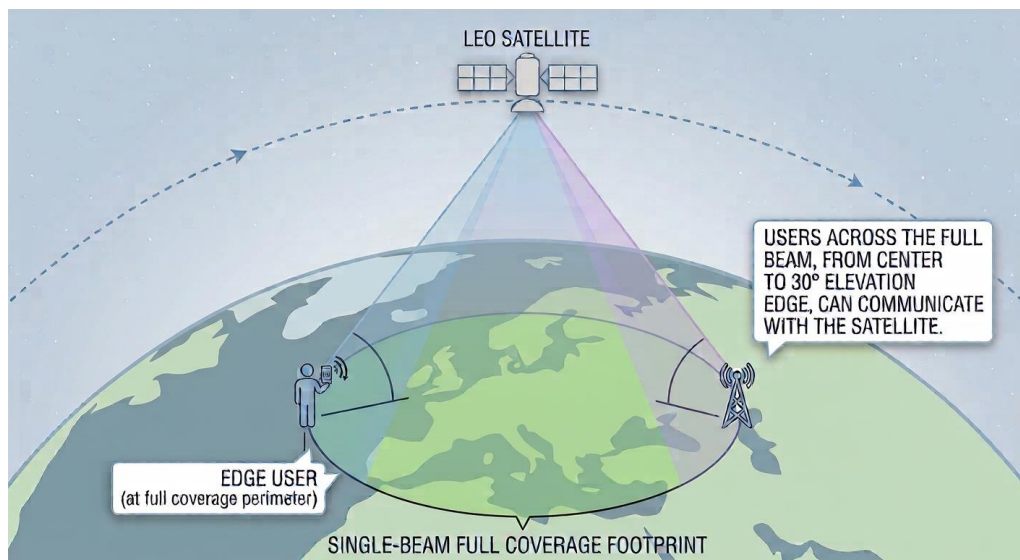


Satellite
protocols



IoT
applications

Direct-to-Satellite IoT protocols



DtS-IoT standard technologies



Licensed spectrum

- Policed medium
- Pay to use

Listen-before-talk

- Possible scheduling

Critical applications

GPS to combat Doppler



Unlicensed spectrum

- Duty-cycle limitations
- Free for all

Transmit-ASAP

- Can be Listen-before-talk

Non-critical applications

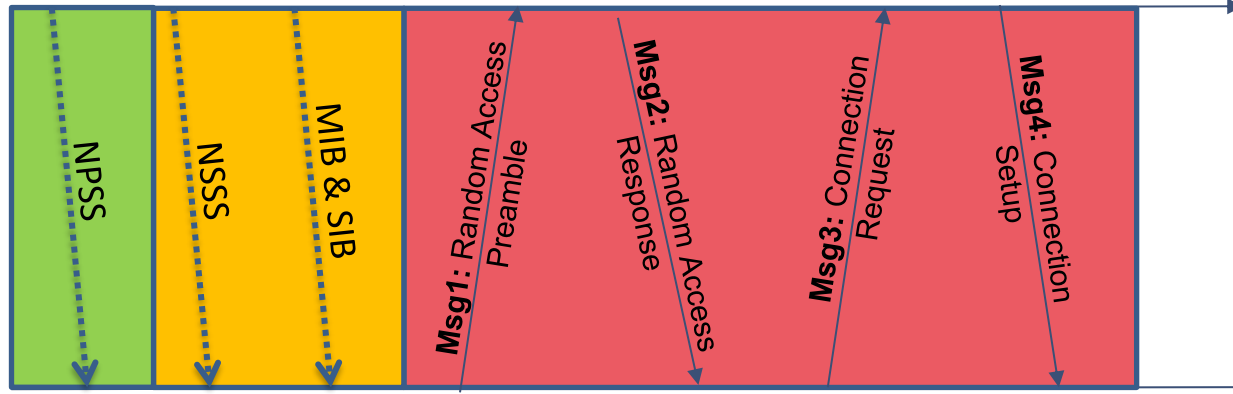
Natively Doppler-resistant



Poster of F. Rolland

Standalone Direct-to-Satellite NB-IoT

eNB



UE Connected

UE

Lack of Synchronization

Doppler effect
Variable distance



Frequency and Time Offset

Lack of Availability

No satellite in range



High energy consumption

High access demand

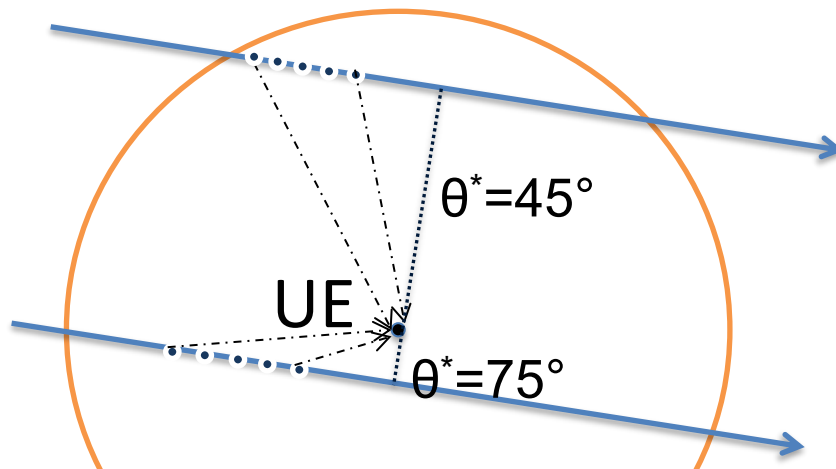
Many collisions



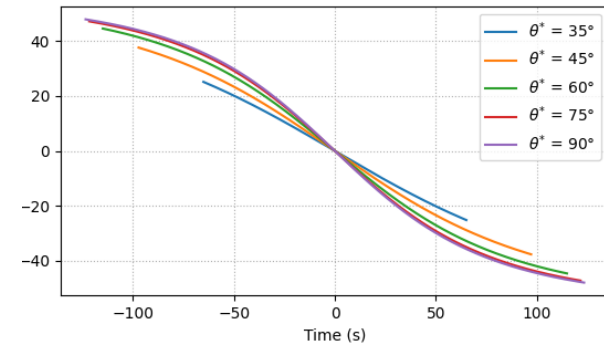
Low throughput



GNSS-free downlink synchronization



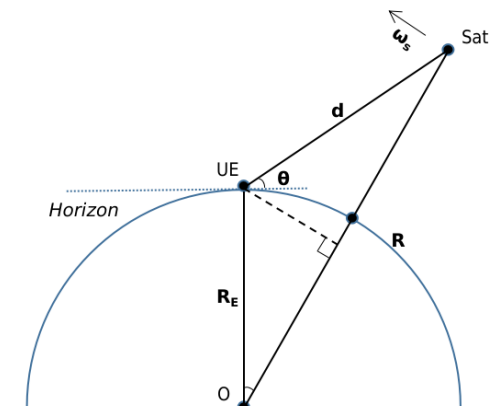
θ^* = maximum elevation angle



Different trajectory $\Leftrightarrow$ Different θ^*

Infer the Doppler curve

- Measurement of the frequency shift of several NPSS
- Compute the best Doppler curve fitting the measurements with the least squares method



Zhou Z, Accettura N, Prévost R, Berthou P. "Lightweight synchronization to NB-IoT enabled LEO Satellites through Doppler prediction." *IEEE WiMob 2023*

Zhou Z, Accettura N, and Berthou P, "A wake-up strategy enabling GNSS-free NB-IoT links to sparse LEO satellite constellations," *IEEE IoT Journal*, vol. 12, no. 12, 2025

Zhou Z, Accettura N, Berthou P, "Increasing the throughput of Direct-to-Satellite Narrowband IoT networks," *IEEE CSCN 2025*

Rolland F, Zhou Z, Accettura N, Berthou P, "Achieving reduced latency and energy efficiency in Direct-to-Satellite LoRaWAN communications," *IEEE WFCS 2025*

Filipe M, Accettura N, "Critical delay-tolerant NB-IoT applications in GNSS-denied Direct-to-Satellite environments," *IEEE MSWIM 2026*

Experimental platform at LAAS-CNRS

DtS eNB/gNB

- Moves fast (~ 7.4 km/s)
- Low altitude (~ 600 km)
- High Doppler shift (± 50 KHz)
- Varying maximum elevation angle



USRP X310

+ modified OAI eNB software adding Doppler shift to downlink signal

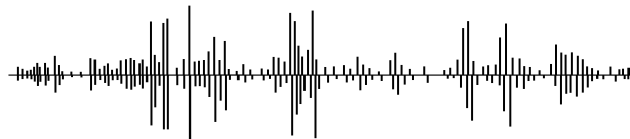


USRP X310

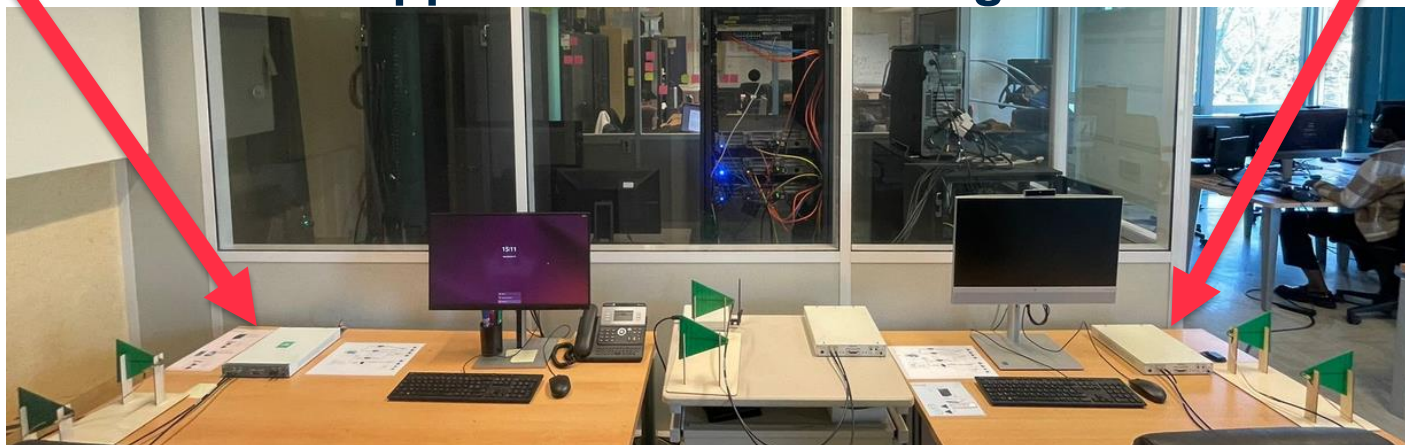
+ original downlink pre-compensation and signal processing

DtS UE

- DtS-enabled UE
- Computes the downlink signal
- Estimates the orbital parameters
- Guesses the Doppler curve

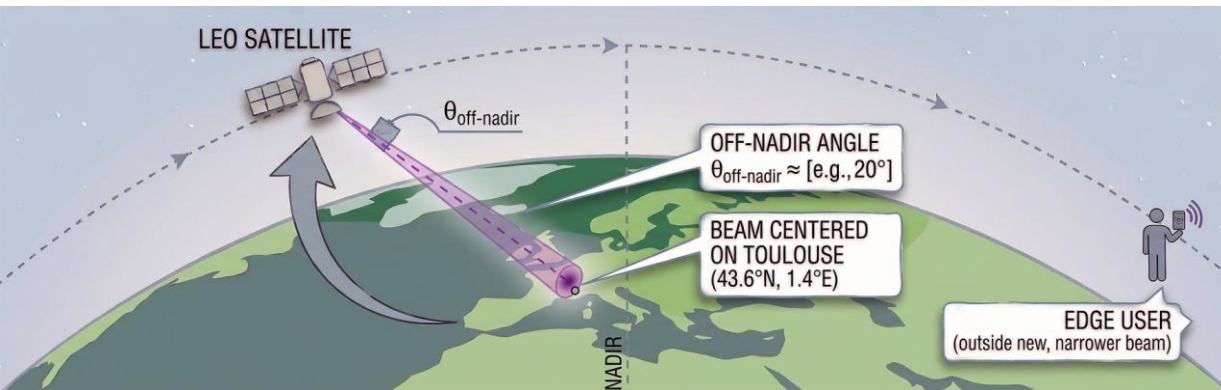


Doppler shifted cellular signal



Poster of M. Filipe

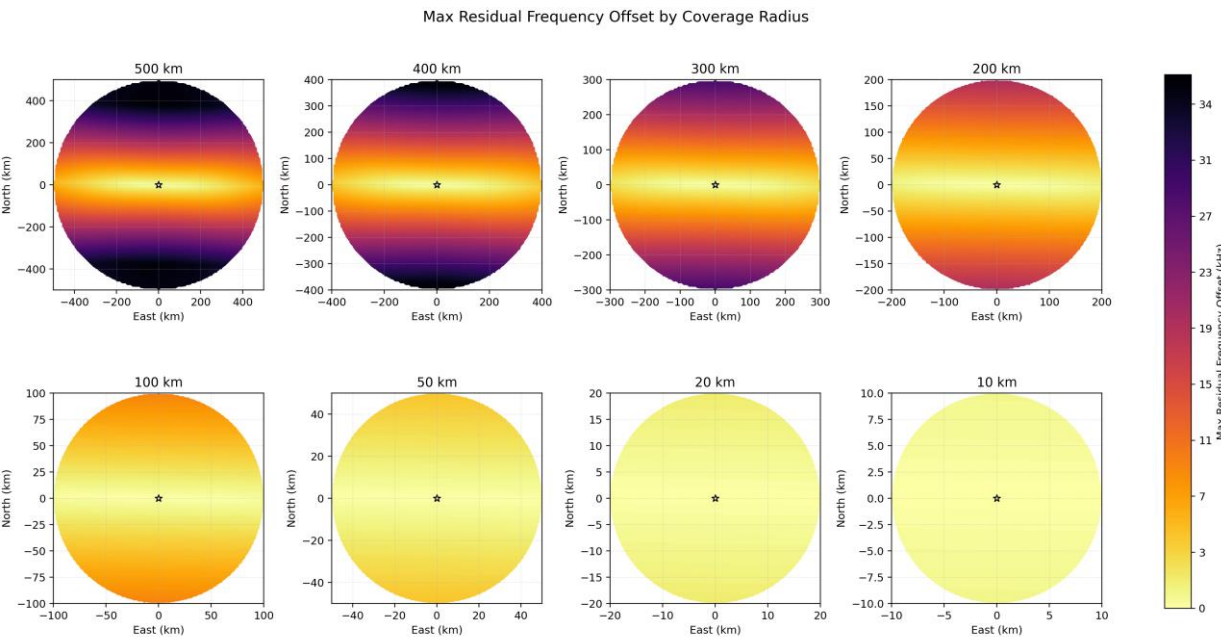
Standard Standalone Direct-to-Device broadband



Earth quasi-fixed cells

- Beam-steering antennas
- Pre-compensation of Doppler and propagation delay on board of satellites
- Possibility of multi-beam antennas

Pre-compensation still needed on ground UEs



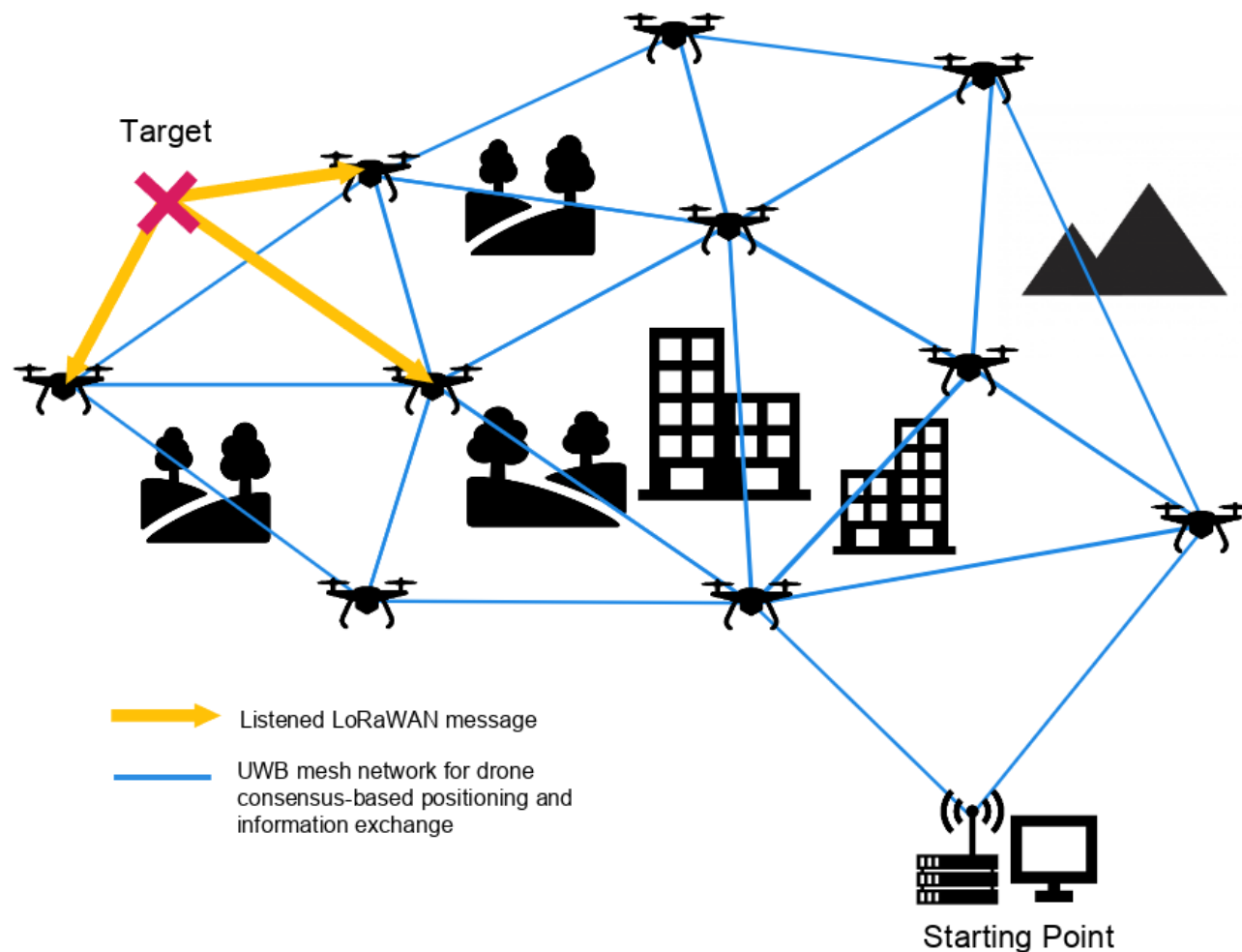
Standard Standalone Non-Terrestrial Networks

**Localization
through swarms
of drones**

anr [©]
agence nationale
de la recherche



**AGENCE
INNOVATION
DÉFENSE**



De Langlais E, Barazzuoli L, Accettura N, "Bidirectional TSCH for swarms of mobile robots in GNSS-denied environments," IEEE MobiWac 2026

Make dialogue happen

Questions?

nicola.accettura@laas.fr