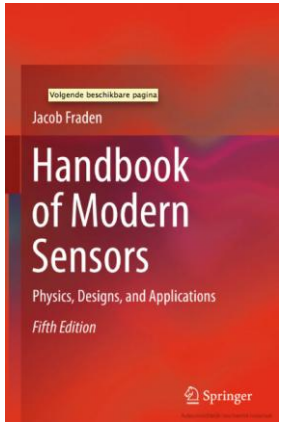
A sensory connected environment:
What is a sensor - sensing?
What (integrated) wireless connectivity is needed?

“A sensor converts input signals of a physical nature into electrical output.”

J. Fraden



KU LEUVEN

A sensory environment: what should wireless connectivity (not) offer?

April 23rd 2026

ELLIIT symposium on sensing and emerging applications

Liesbet Van der Perre, Liesbet.vanderperre@kuleuven.be

Special thanks to Bert, Jarne, Gilles, many others

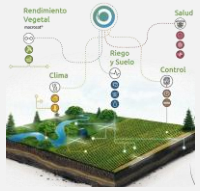
REINDEER

SUSTAIN 6G

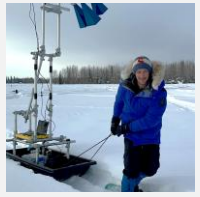
AMBIENT-6G

→ creative designs to tailor for applications

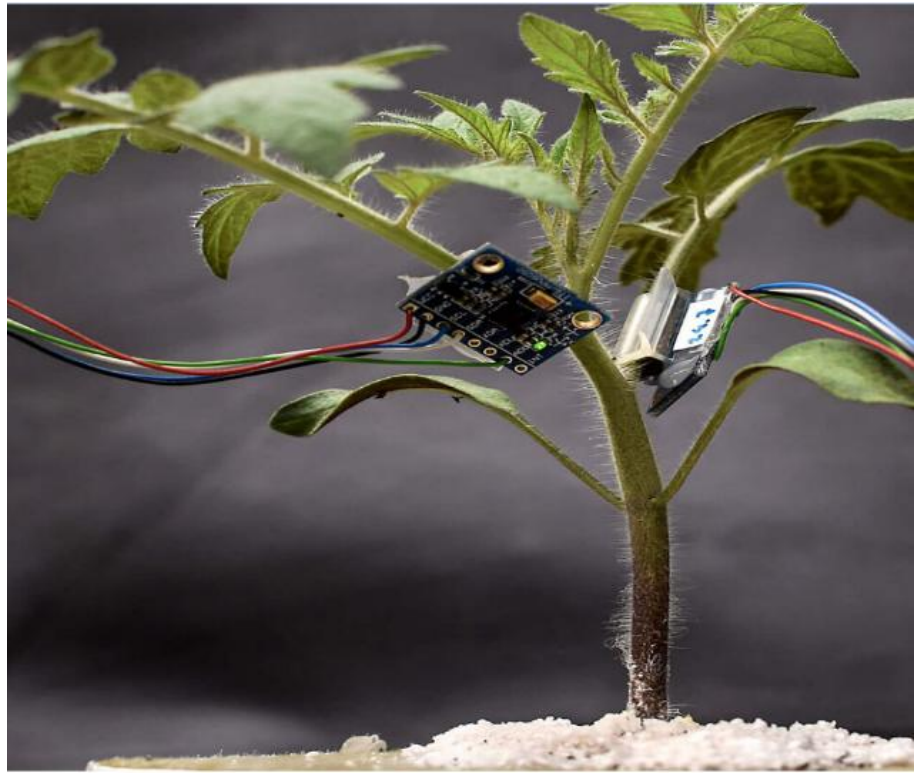
Sensing plant health in greenhouses



Sensing for precision farming at large scale



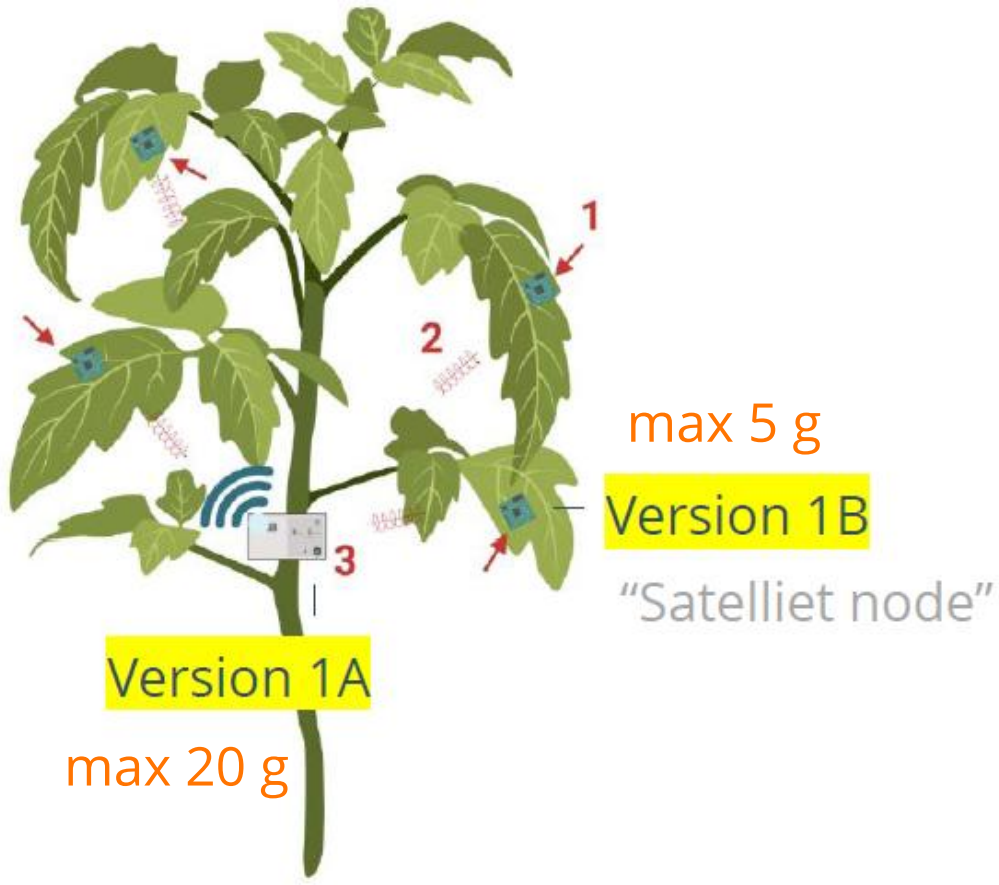
Sensing essential climate variables



Could we release this plant from its chains?

Goal: Plant-wearable Wireless Sensing Solution for Autonomous Monitoring

Plant movement sensor: (ultra) constraint design

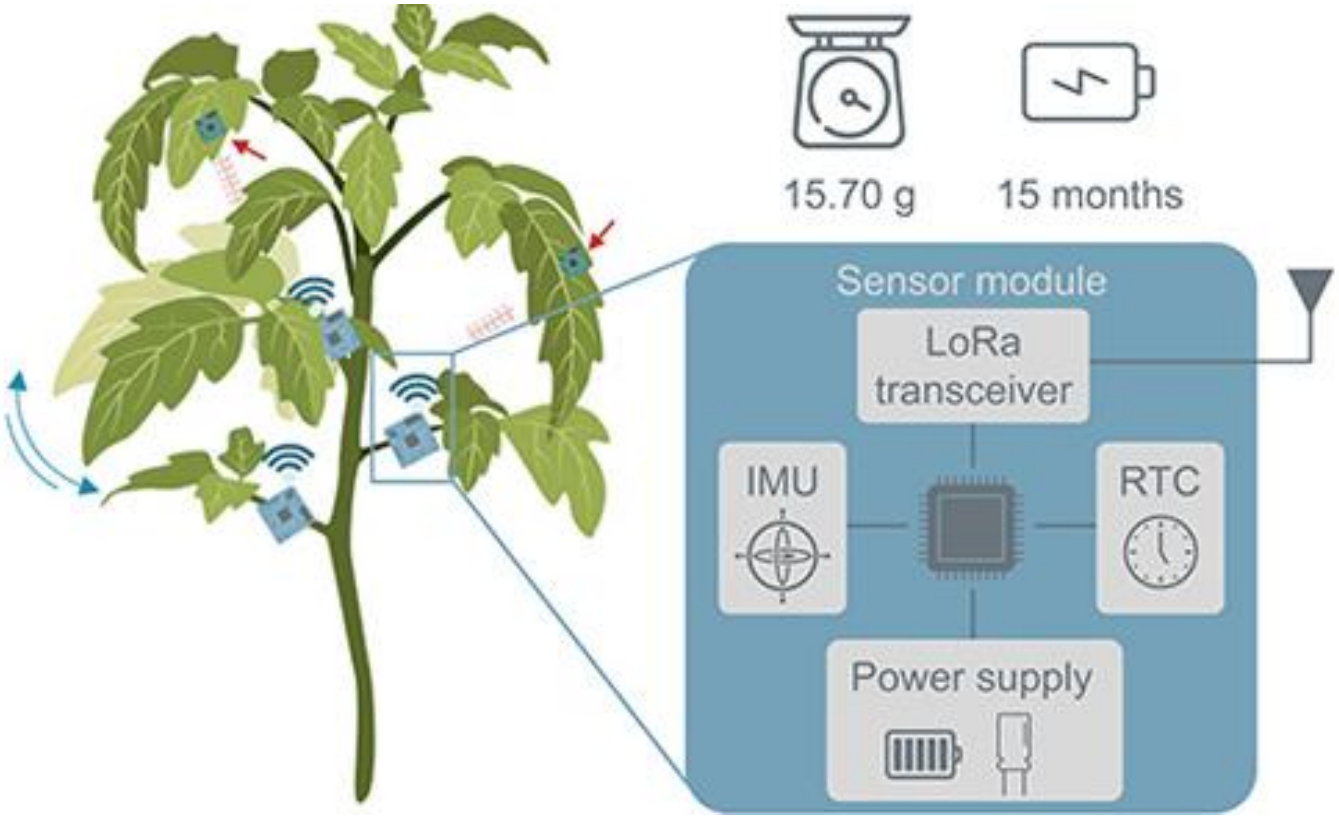


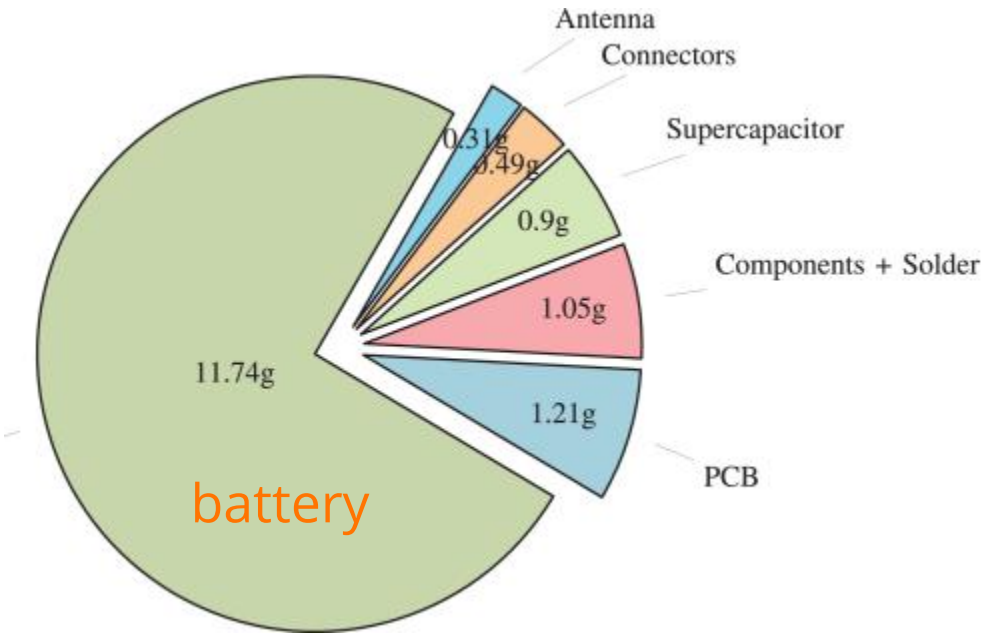
from 'BER vs SNR'

to 'energy(nJ)/bit'

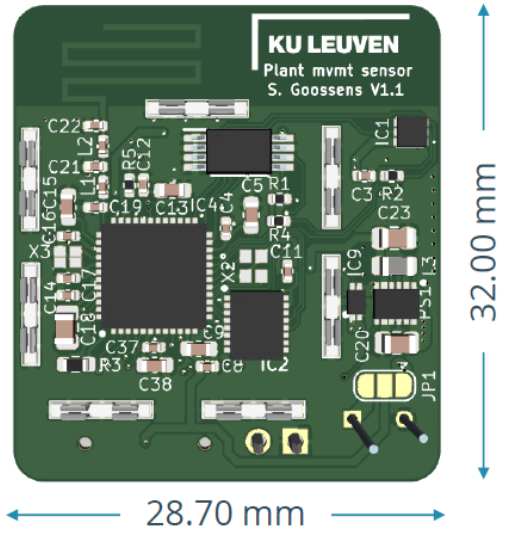
to 'bit-meter/g'?

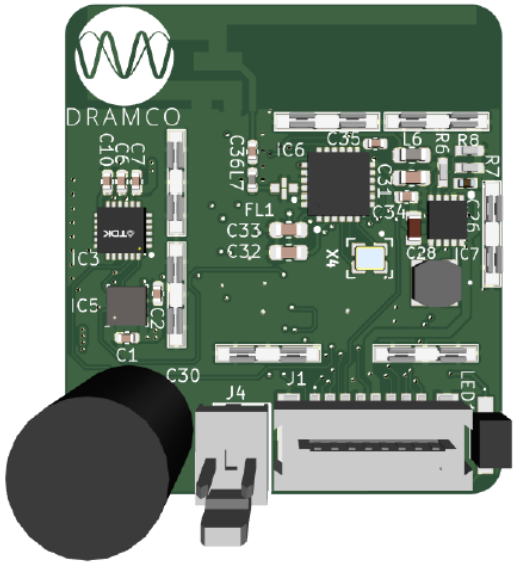
Petiole sensor: architecture of the ‘ISAC’ node on a diet

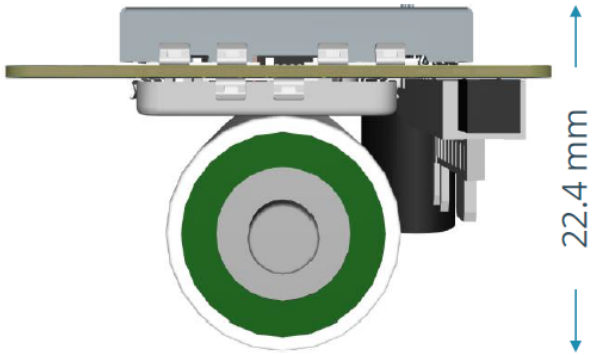




Petiole sensor: design of the node

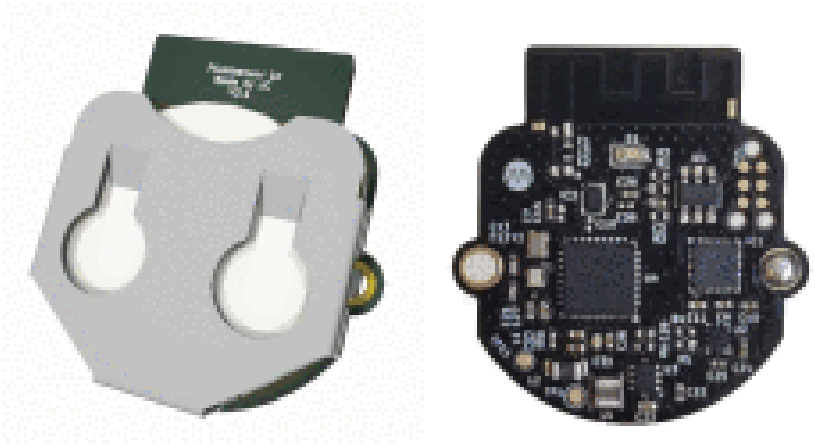




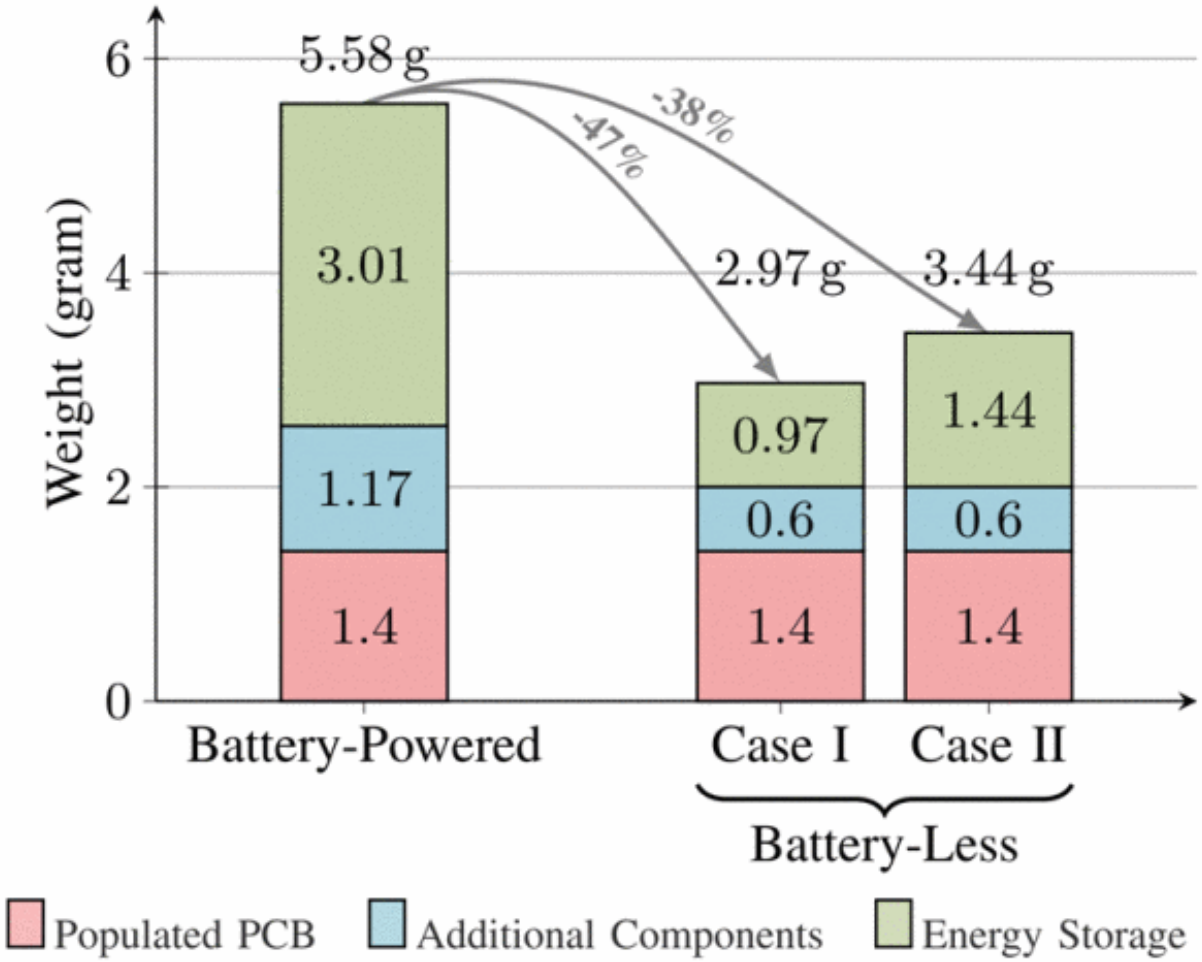


S. Goossens *et al.*, "Plant-Wearable Wireless Sensing Solution for Autonomous Monitoring," in *IEEE Sensors Journal*, vol. 26, no. 7, pp. 9484-9492, April 2026, doi: 10.1109/JSEN.2026.3651894.

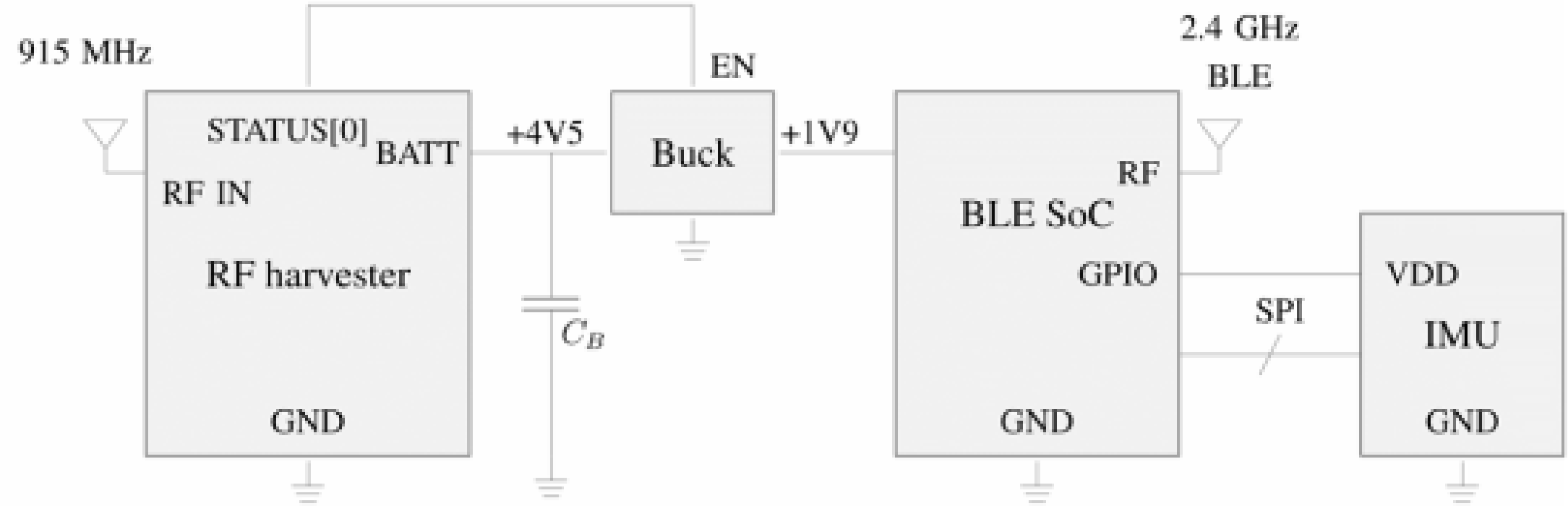
Leaf sensor: options for node on an RF-diet?



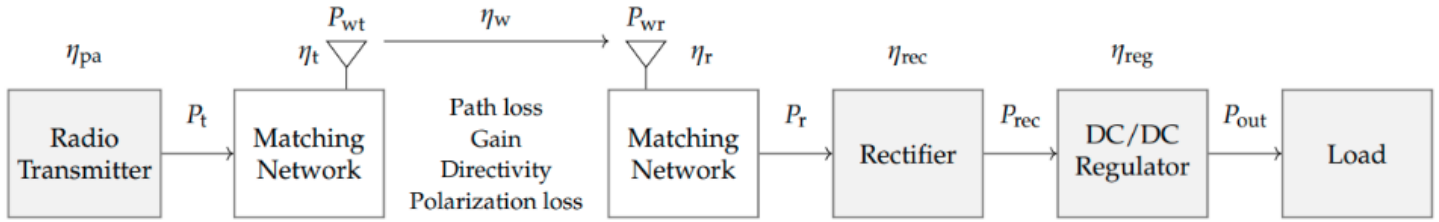
Case I:
only accelerometer -> pitch and roll leaf angles
Case II:
accelerometer & compass -> all 3 Euler angles



Leaf sensor: architecture of the ‘ISAC’ solution



(RF) Wireless Power Transfer: limited!

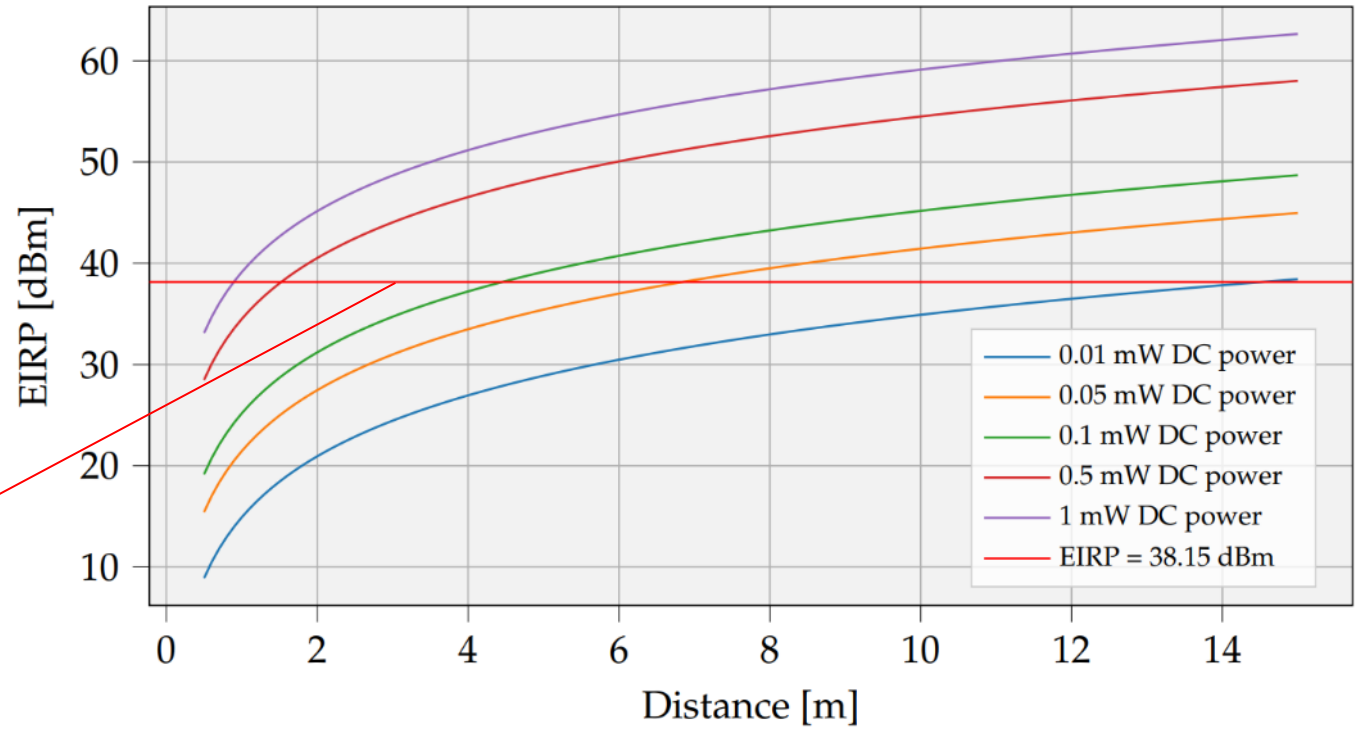


SISO

Energy harvester

↓

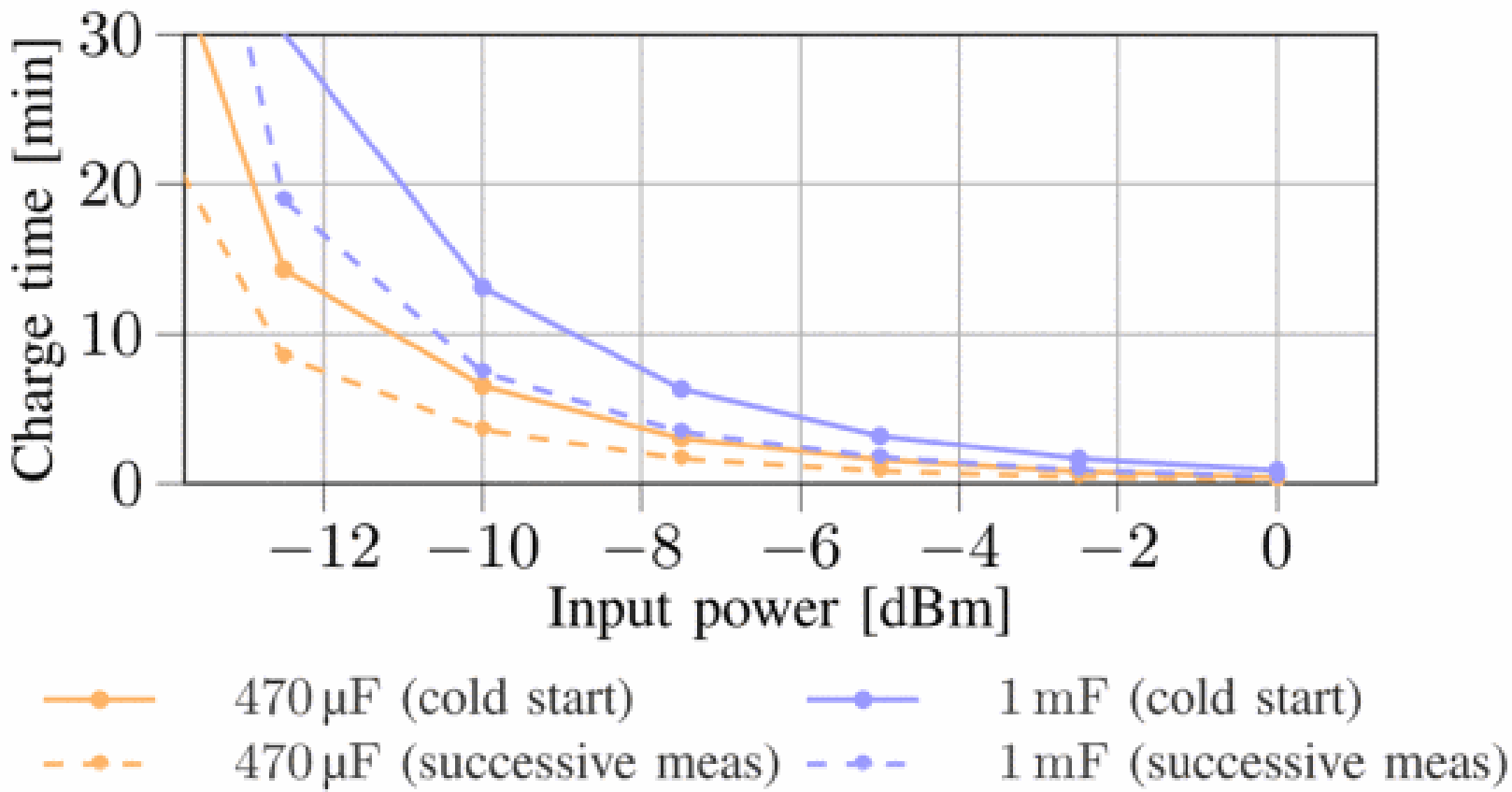
Evaluation board
AEM40940



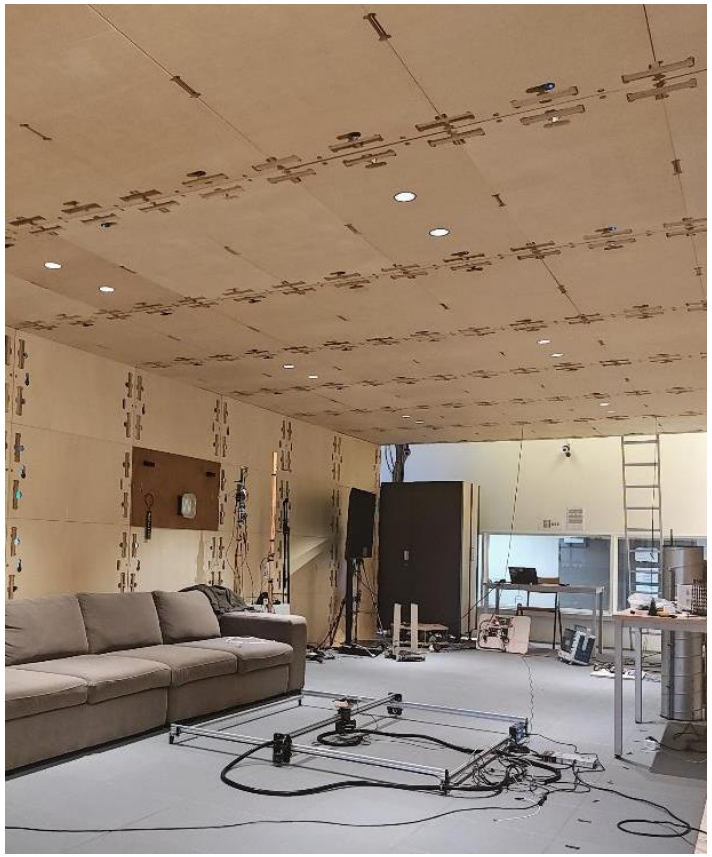
EIRP is limited by standards
E.g., ETSI EN 302 208

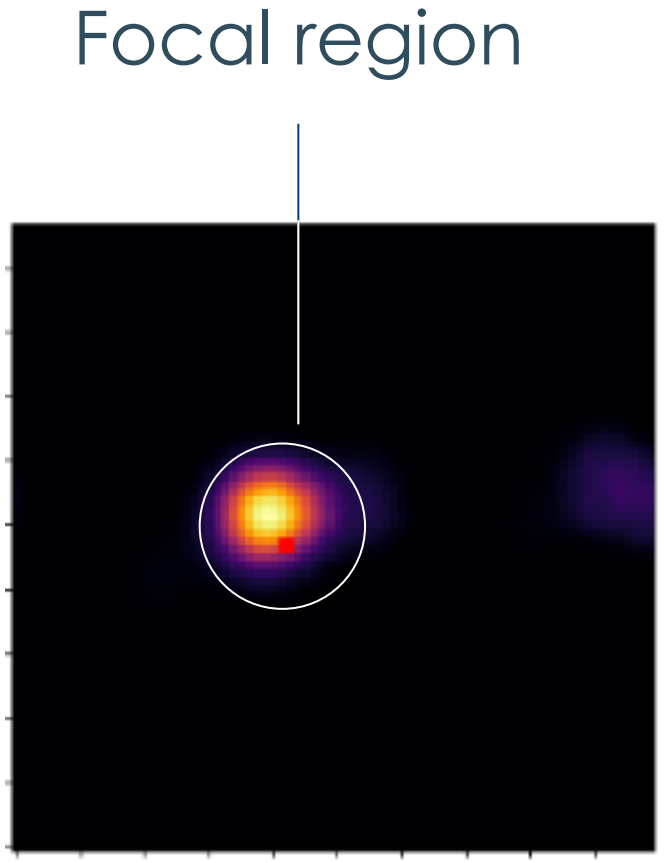
With 38.15 dBm equals to 6.5 W of radiated power

No free lunch: sensors may need to be patient



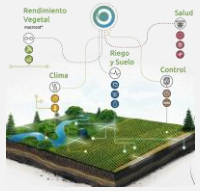
Charging from many distributed RF Tx: efficiency boost!



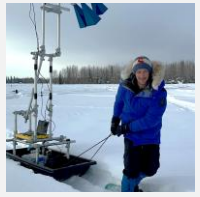


REINDEER

Sensing plant health in greenhouses

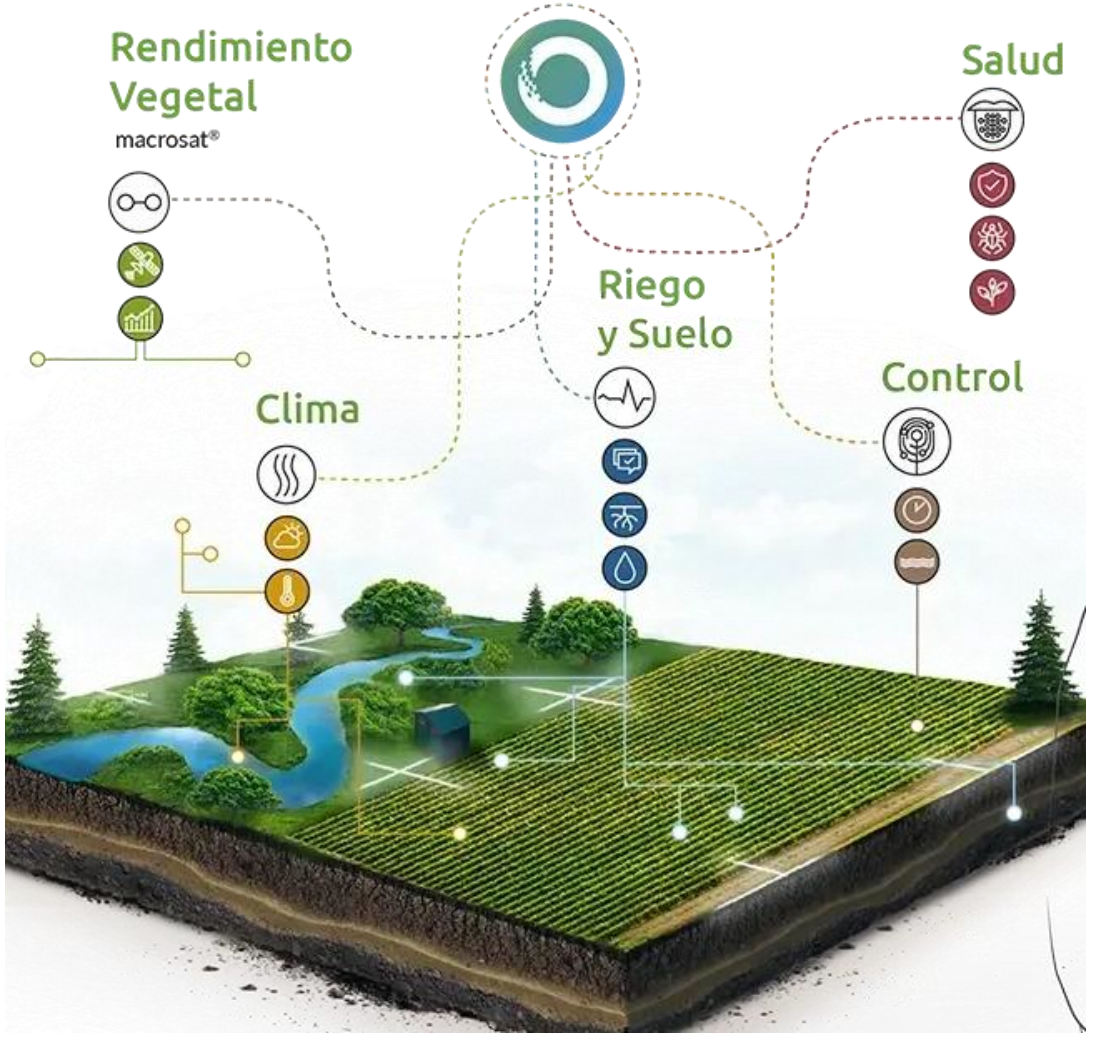


Sensing for precision farming at large scale



Sensing essential climate variables

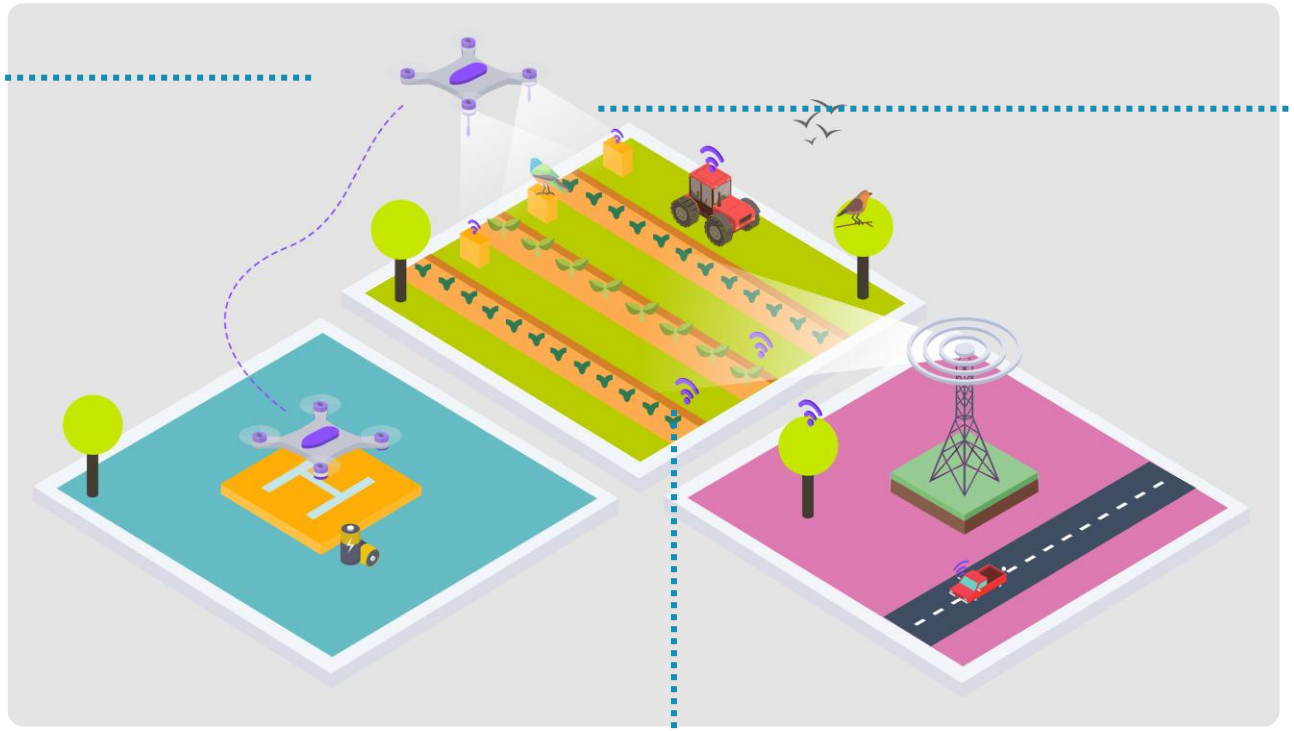
Sensing for large-scale farming can offer economic and ecologic benefits



A ‘Drone Area Network’ (DAN) at the rescue to periodically collect non-time-critical data

Where is 4G/5G when you need it?

drones support wide-area coverage

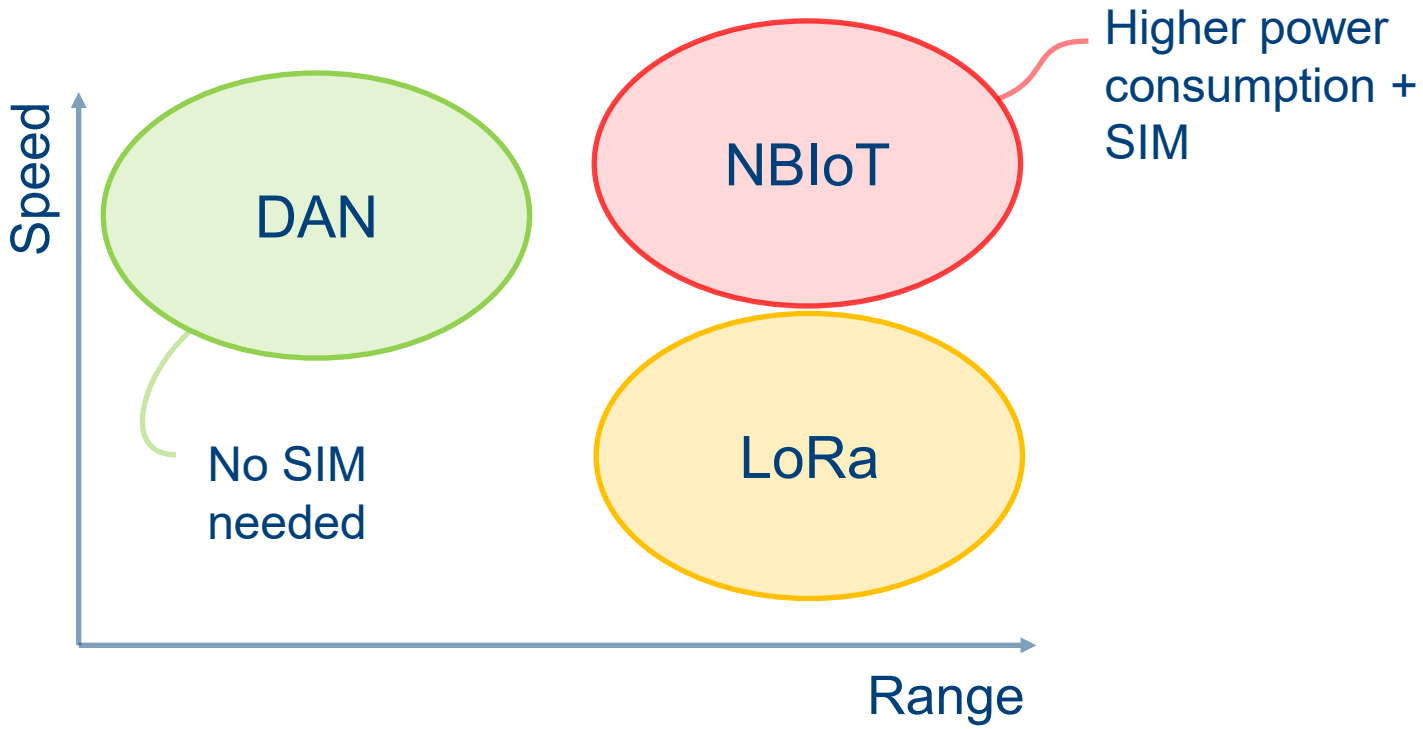


short-range, high-throughput efficient data offloading

low-cost sensing modules (‘SIM-free’), minimal infrastructure

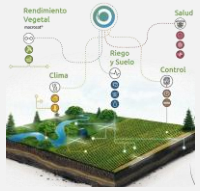
‘Drone Area Network’ (DAN): Progressing the concepts

LCA-aware: **reuse** existing long range low throughput **hardware**
as short-range, high-throughput link

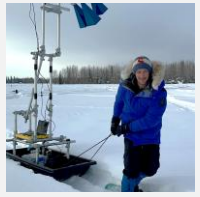


Can we do better than NBIoT in terms of energy/bit?

Sensing plant health in greenhouses



Sensing for precision farming at large scale



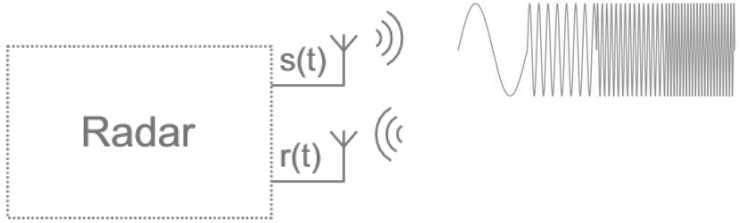
Sensing essential climate variables

Introducing the WAVETRAX project: WAter and VEgetation Tower RAdar eXperiments for improved climate monitoring

Our mission

The WAVETRAX project aims to enhance climate monitoring by advancing our understanding of active microwave remote sensing and its response to rapid sub-daily land-atmosphere interactions. Seasonal changes in snow, soil moisture, and vegetation play a vital role in water resource availability, ecosystem health, and climate regulation. Through tower-based RADAR observations and satellite data analysis, we seek to unravel complex interactions between microwaves and the Earth's surface, providing key insights into Essential Climate Variables (ECVs) such as soil moisture, snow water equivalent (SWE), and vegetation properties.

www.belspo-wavetrax.be



UWB PULSED RADAR

- Short pulses are transmitted, and reflections are registered
- For one measurement:
  - Multiple pulses
  - Results integrated over time (SNR ↑)
- Fast, dedicated, WB electronics

UWB STEPPED FREQUENCY CONTINUOUS WAVE

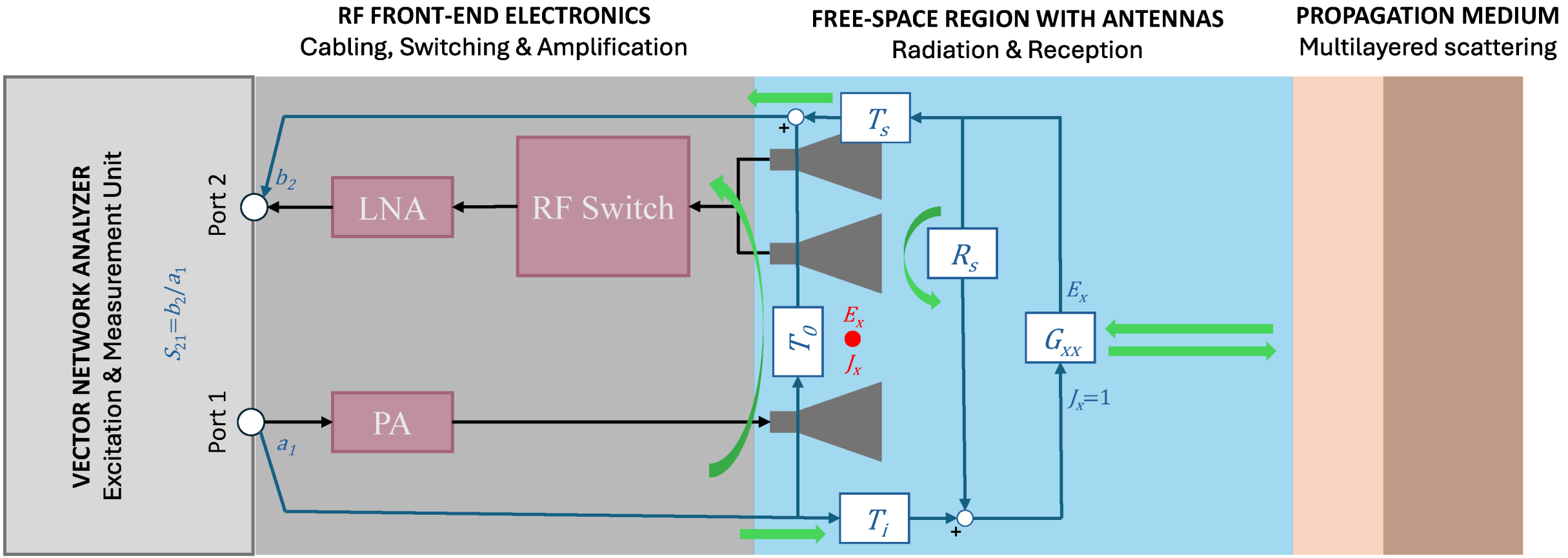
- Consecutive, unmodulated carriers at different frequencies
- Narrowband sub measurements (takes more time)
- General purpose electronic systems

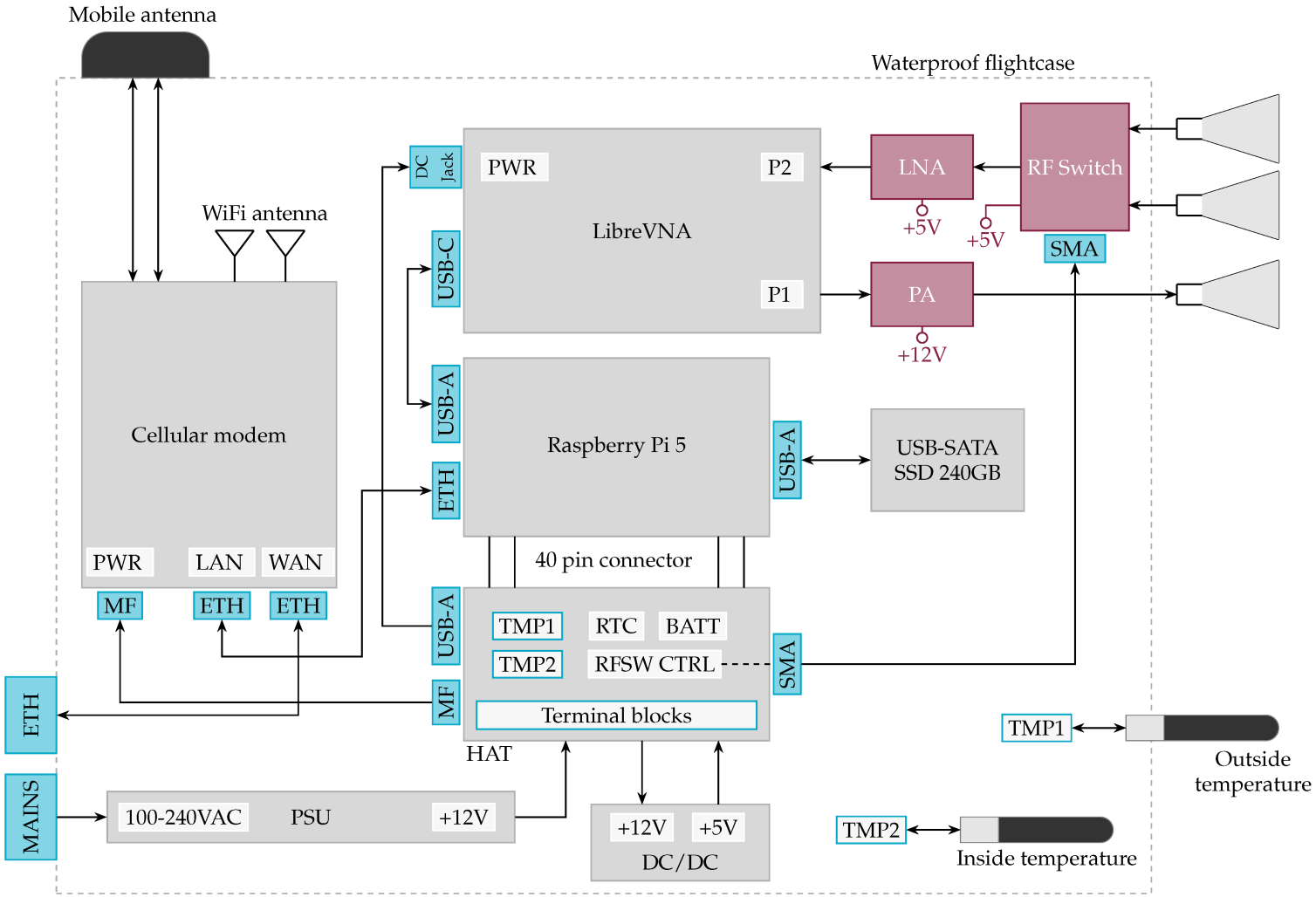
@ Switzerland,
grid-powered
soil–snow profile
C-band (~5 GHz)

@ Belgium,
solar-powered
soil–vegetation profile
L-band (1-2 GHz)

Challenges: radar system solution to be built with low-cost existing HW
+ robustness, stand-alone performance, constant network connection

The bi-static radar frequently senses the slowly changing (~minutes) phenomena

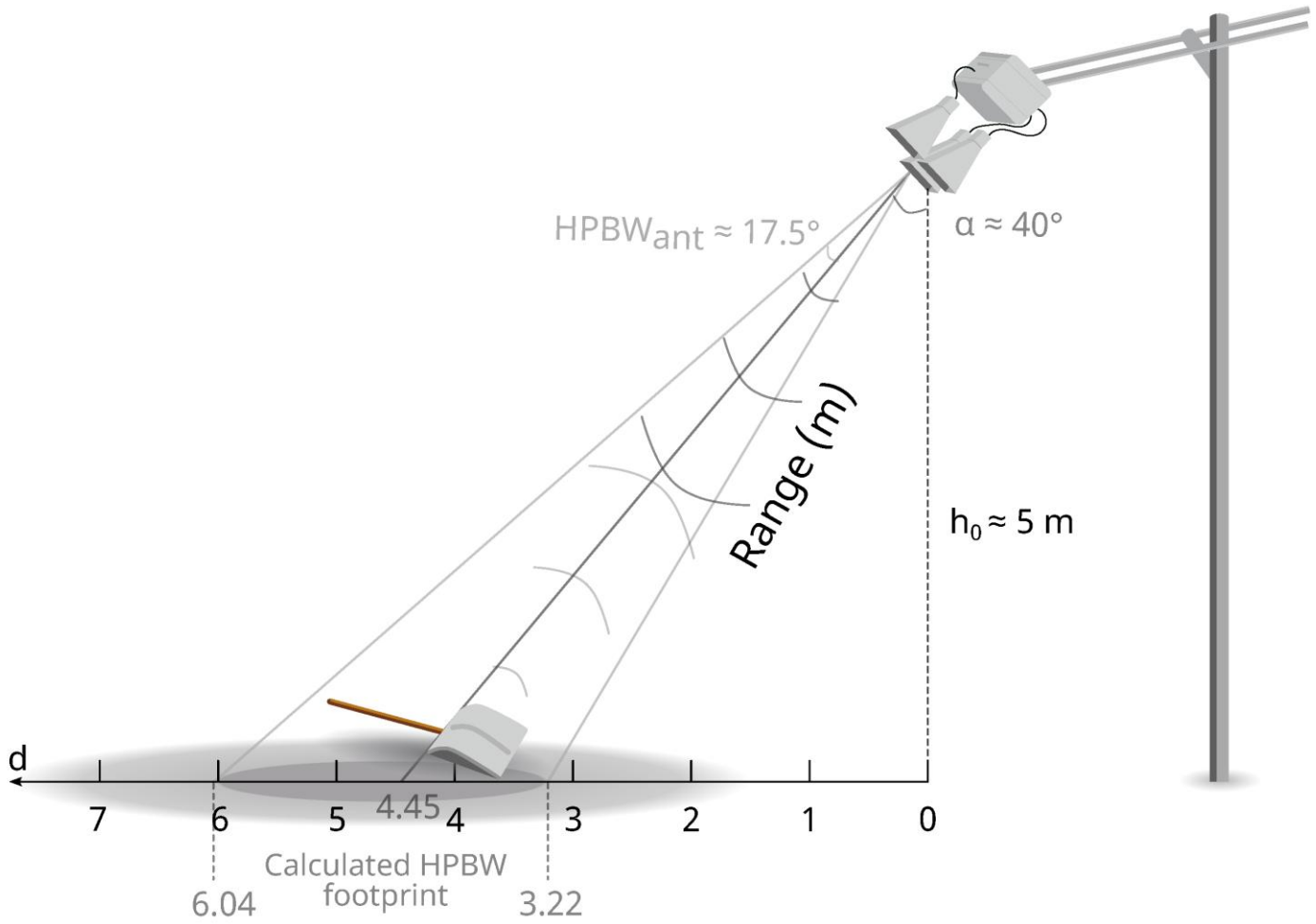




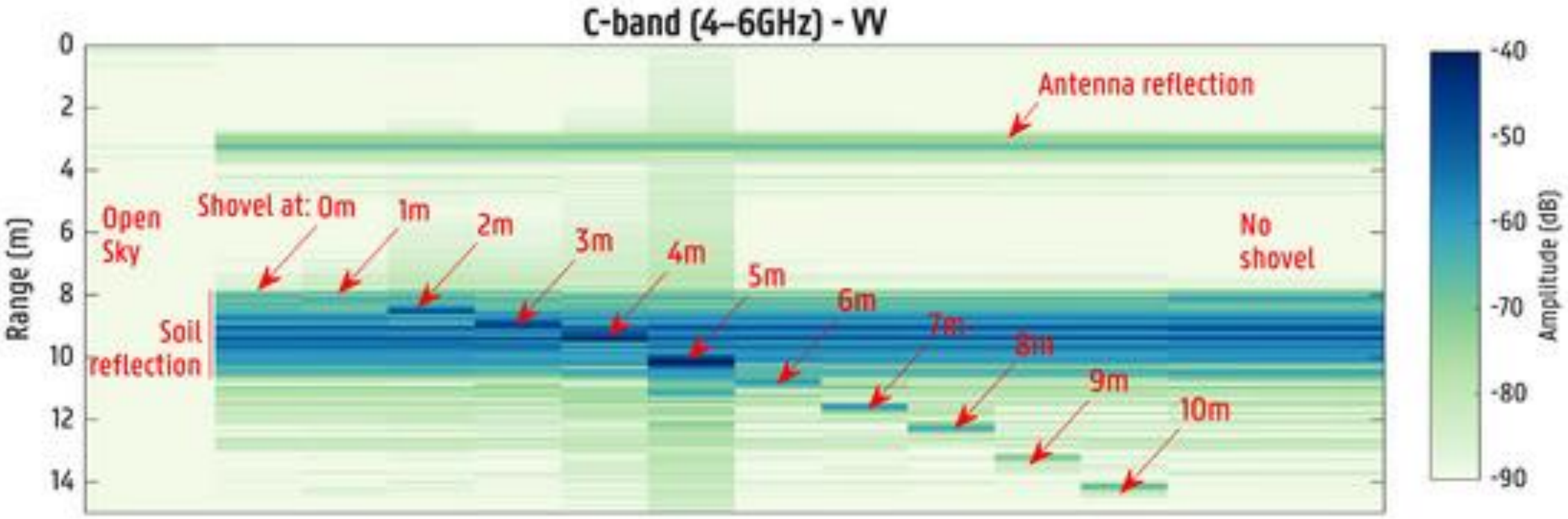
This ISAC system integrated in a waterproof flight case went for some trips

Jarne Van Mulders et Al., Design and Implementation of an SFCW Radar Platform for Environmental Monitoring. *NDT* **2026**, *4*, 6. https://doi.org/10.3390/ndt4010006

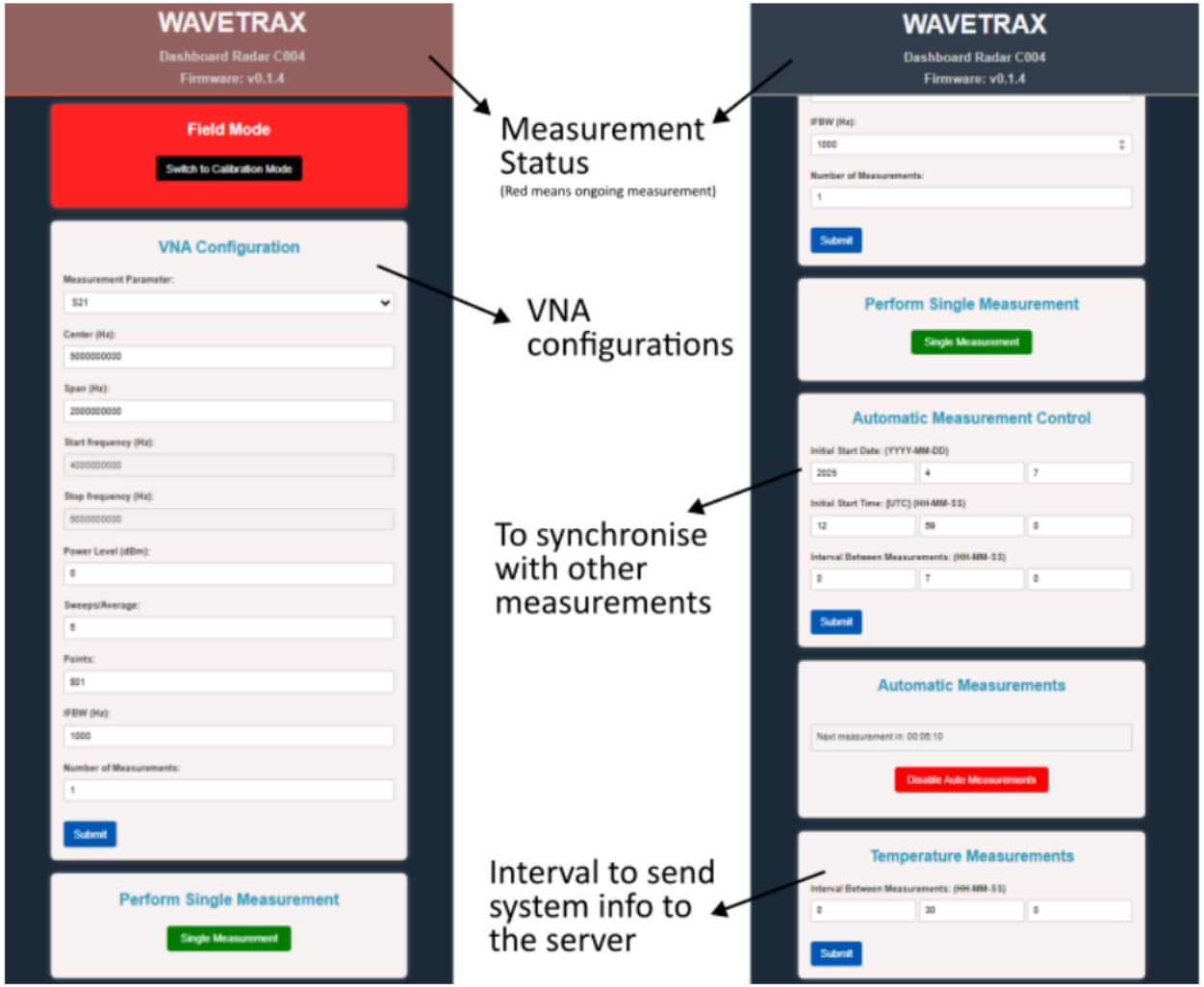
Checking the operation with the ‘shovel test’



Processing measurements to obtain the results of the ‘shovel test’



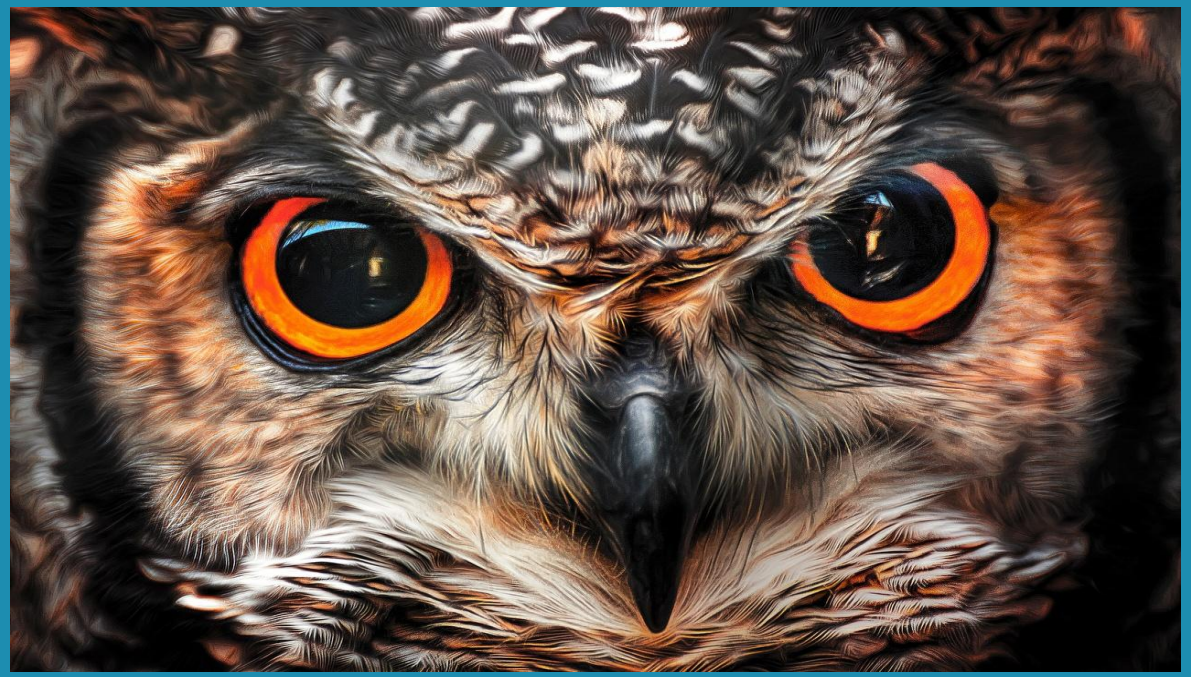
Real-time dashboard allows to follow up remotely snow, environmental conditions … and system failures



Preparing a radar set-up for more ‘blue-sky research’

Designing a mobile set-up (snow-scooter travelling) and a static one
Melting ice shelves Of AnTarctica (MOAT)-project

http://www.antarcticstation.org/



Sensing for emerging applications: wireless connectivity is a magic ingredient, if used wisely!