Zero Energy Development

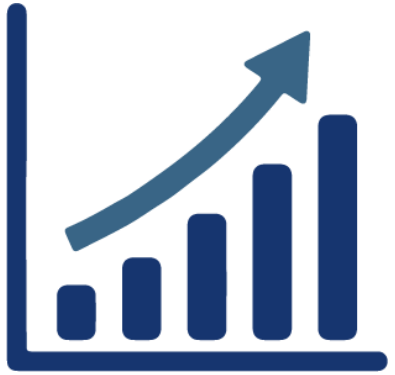
Smart & Maintenance-Free Sensing

ZED: Zero Energy Development

- Startup TU-Delft
- Ultra low-power sensing
  - Energy harvesting
  - Extreme environments

Batteryless

Wireless



Scalable

The Team

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Ir. Sujay Narayana

Kiran Muthal

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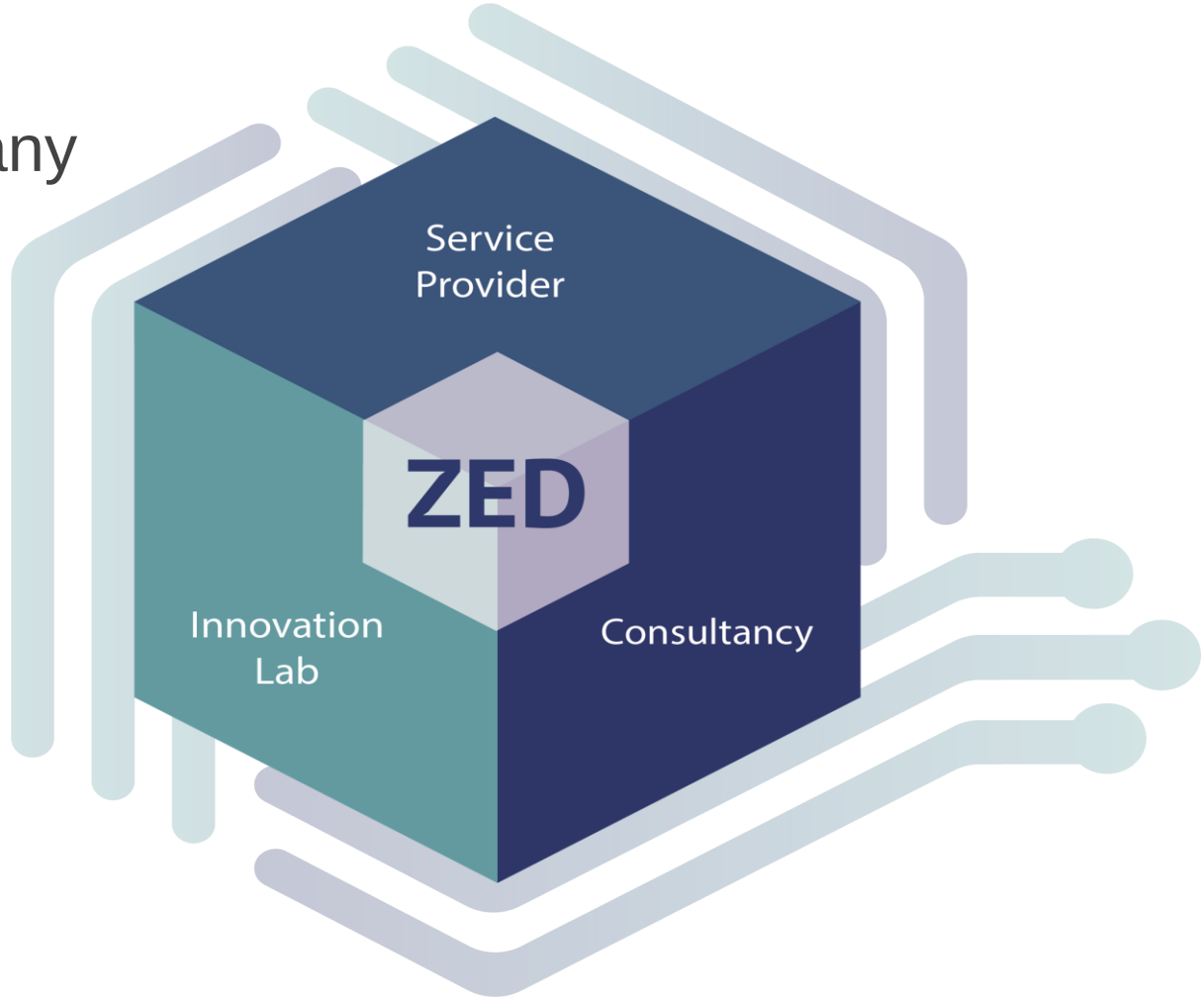
Business

- knowledge transfer-based company
- Staying connected with TU-Delft
- Springboard of innovation
- Our mission



Switch paper

2019 IEEE 5th World Forum on Internet of Things (WF-IoT)

Pushing the Boundaries of IoT: Building and Testing Self-powered Batteryless Switch

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***Abstract*—Battery operated systems are bulky, expensive, and often add unnecessary burden because of their maintenance. They are also harmful to the environment. However, the design and development of batteryless systems are highly challenging as the energy needs to be harvested from user's activities or the environment. The harvested energy also varies with the activity, environment, and other aspects. In this paper, we present a system employing an energy harvesting switch to power a low-power radio, which transmits data wirelessly in 2.4 GHz ISM band. We provide the details of the design of our system and modules. We evaluate our energy harvesting switch which we built in-house. With evaluations, we show that our system works well, and we demonstrate the transmission of 27 bytes at 200 kbps data rate. Further, by varying the transmission power between -10 dBm and 5 dBm, we transmit data packets of length between 19 and 27 bytes with a single press of the switch.**

***Index Terms*—batteryless, energy harvesting, switch, zero-energy**

I. Introduction

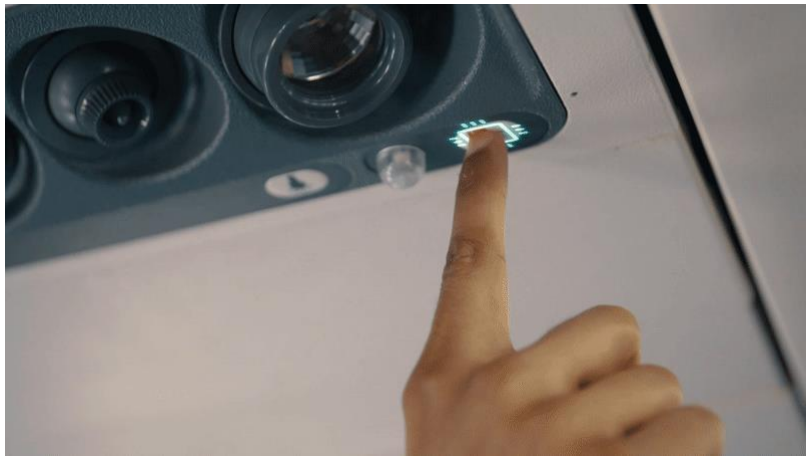
mature enough to support such batteryless devices [9]. This can help in the rollout of batteryless systems.

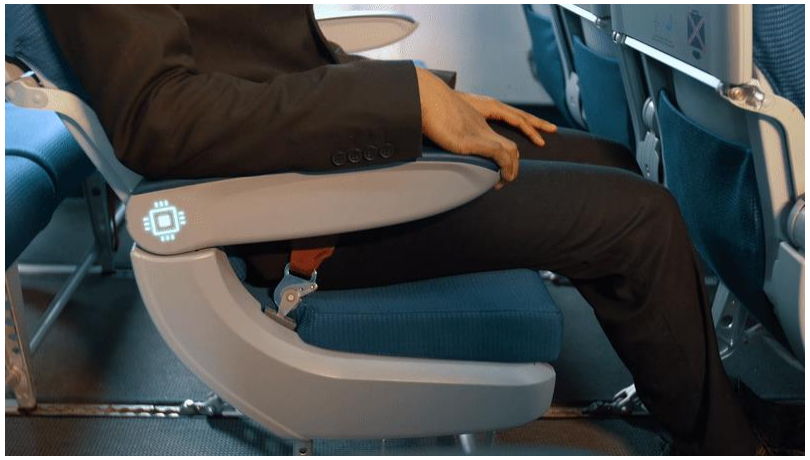
Batteryless systems can be used in several places like aeroplanes, buses and trains. For example, calling a flight attendant requires pushing a button connected through wires to actuators [10]. The 'stop' indication by the passengers in buses is also activated in a similar way. Such simple systems of sensors and actuators can be replaced by batteryless systems, also using wireless communication. This will not only reduce the cost of wires, but also lower the amount of fuel that is needed for the operation. Regarding the maintenance of systems powered by batteries, frequent battery replacement is labour intensive and, in many situations, even impractical due to physical or deployment conditions (e.g., pillars of bridges, on top of wind turbines, etc.). Furthermore, batteries generate a considerable carbon footprint and greenhouse gases.

One of the main components of IoT devices is a commu-

New Ultra Low Power MAC-Protocol

- Large amount of transmissions within a small area
- Event based energy harvesting
- 250µ Joule
- Transmit only once





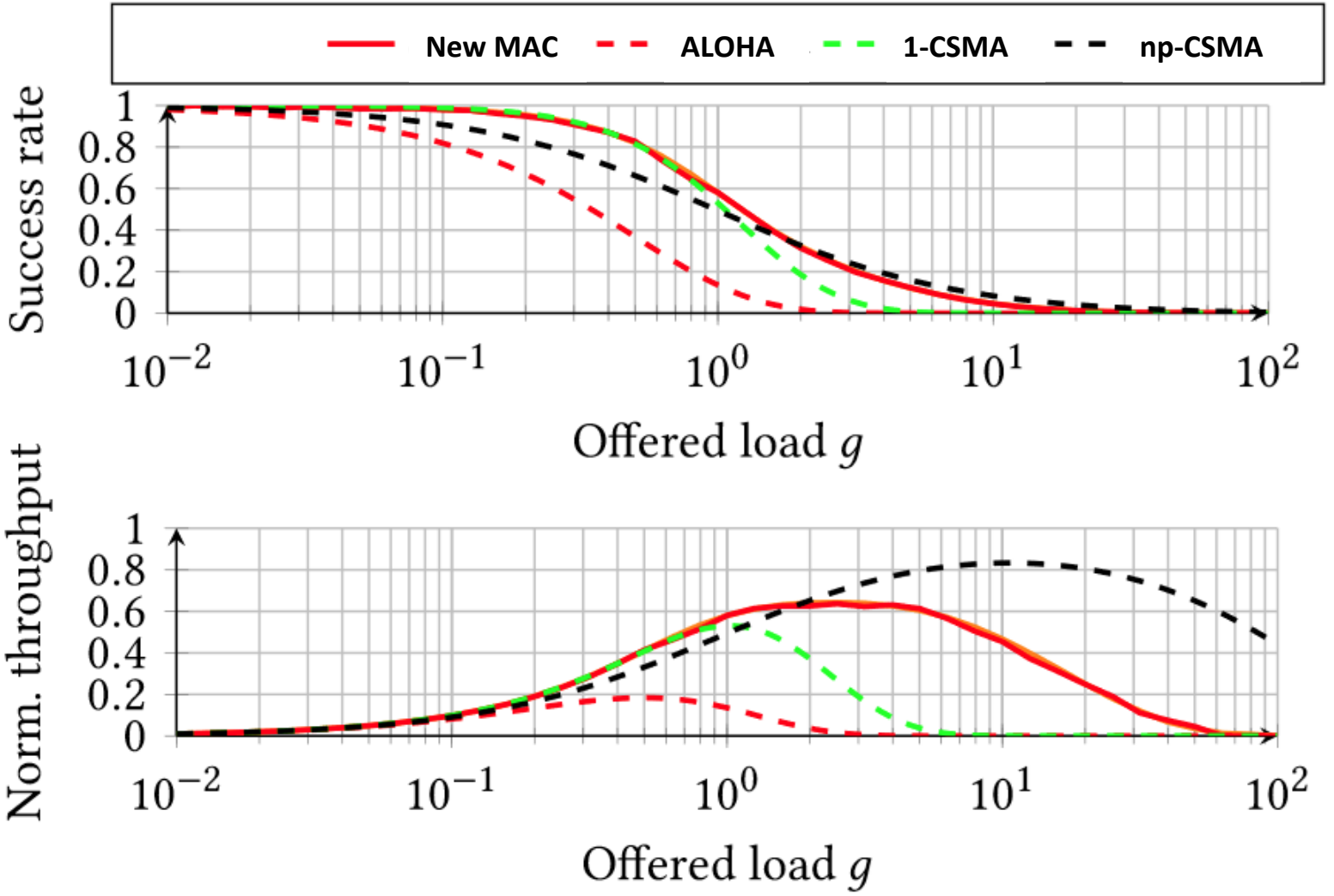
Ultra Low Power MAC-Protocol

- ALOHA
- 1-CSMA
- np-CSMA

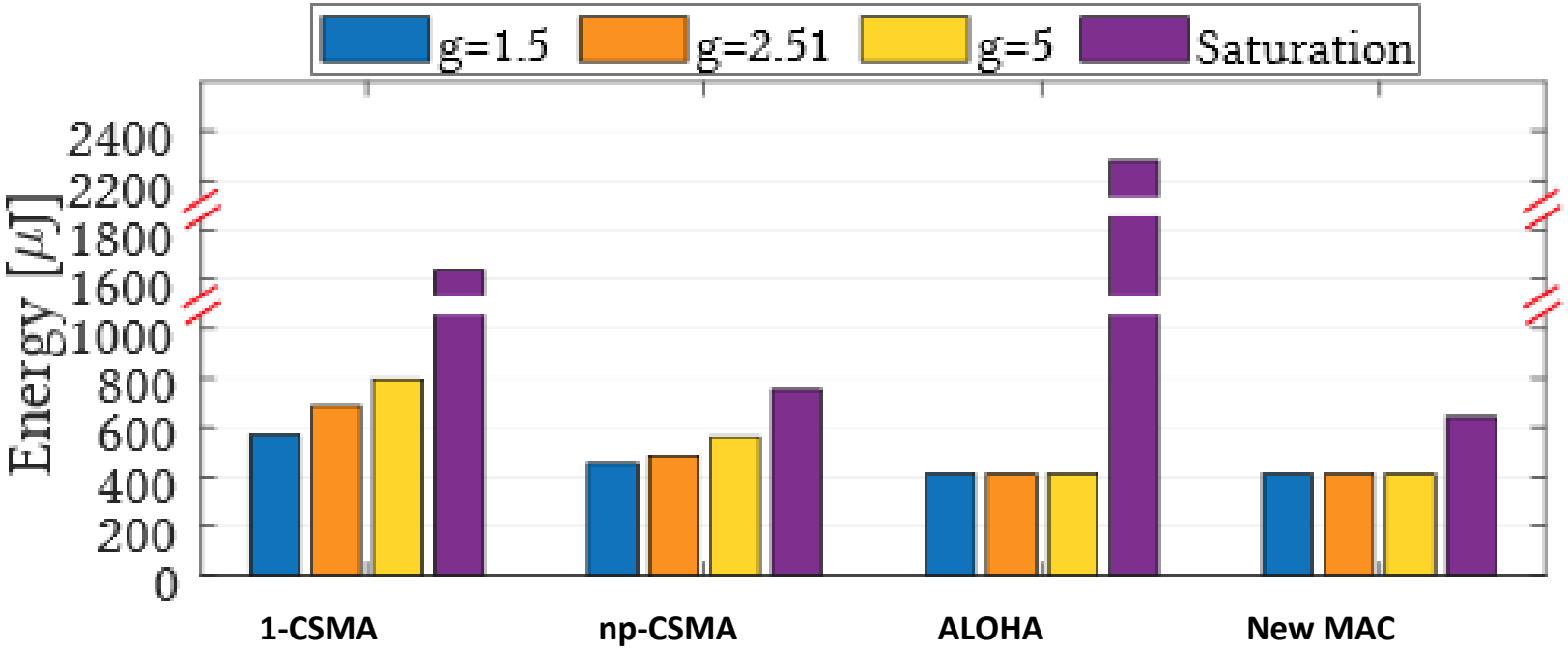
Ultra Low Power MAC-Protocol

- Fully passive
- RF-Information harvesting
- Synchronises packet transmissions
- Differentiates based on distance

Ultra Low Power MAC-Protocol



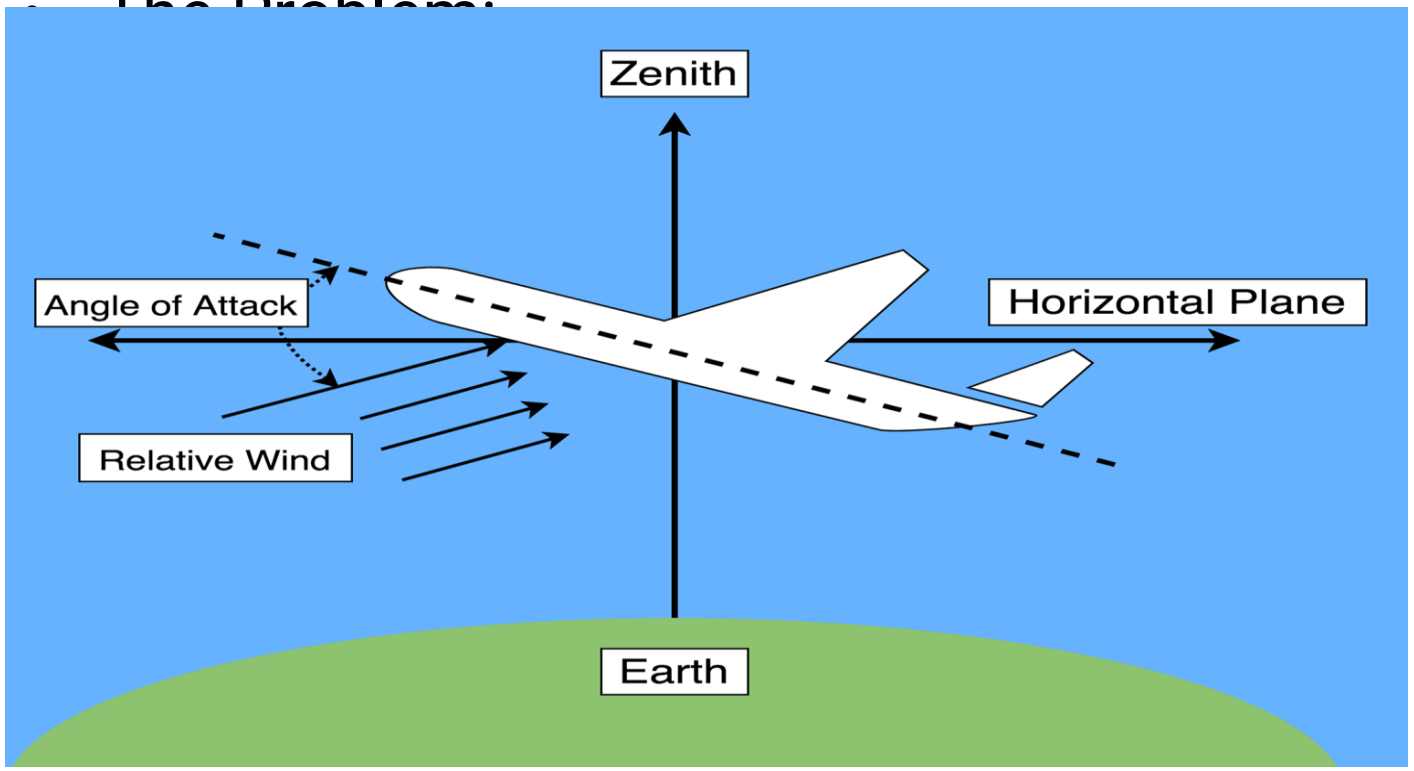
Ultra Low Power MAC-Protocol



Airbus

ZED Won the Airbus Fly Your Ideas Competition

Wind sensors



"...the left and right angle of attack values deviated by **59°**" [1]

[1] Aircraft Accident Investigation Bureau Interim Report, Ethiopian Civil Aviation Authority, Ministry of Transport (Ethiopia), 2020

Problem Setup

1. **Reliability**
    a. Simultaneous measurement (Independence)
    b. Self Powered (Energy Harvesting)
    c. Range
    d. Accuracy
2. **Form factor**
    a. Size
    b. Cost
    c. Computational simplicity (on low power MCU)
    d. Low-power radio communication

Can we design a reliable small sized sensor that can independently measure AoA and wind speed and thus increase safety of flights?

The Solution: Hermes

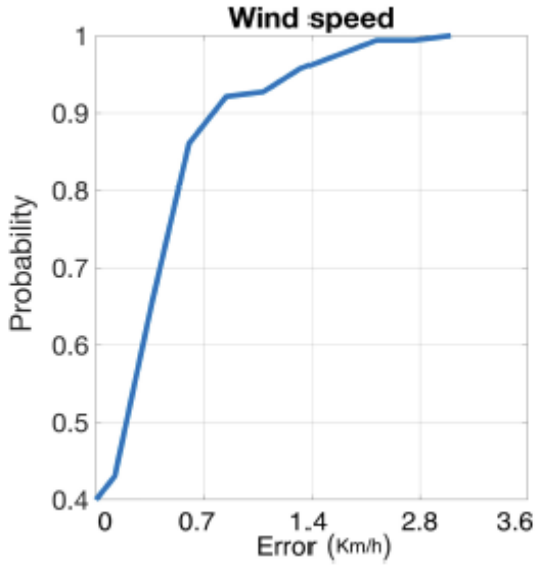
- **Hermes:** Wind energy harvesting wireless system for sensing angle of attack and wind speed
- Empirical model of sensing by characterization of voltage generated by of **piezo films**.
- Utilize aeroelastic **flutter** to harvest energy and simultaneously sense.

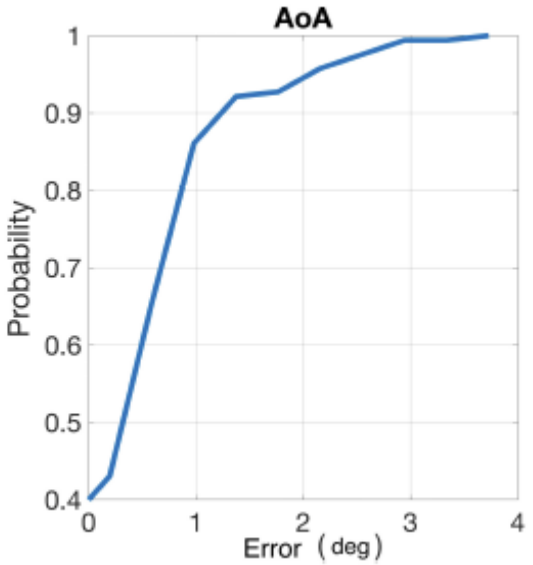
Energy Harvesting Sensing

- **Patented technology** with our own NSR Algorithm to simultaneously measure Angle of Attack and Wind Speed

- Working on further refining the technology to make it robust and start **field trials**

An Energy Harvesting Sensor using Flutter!

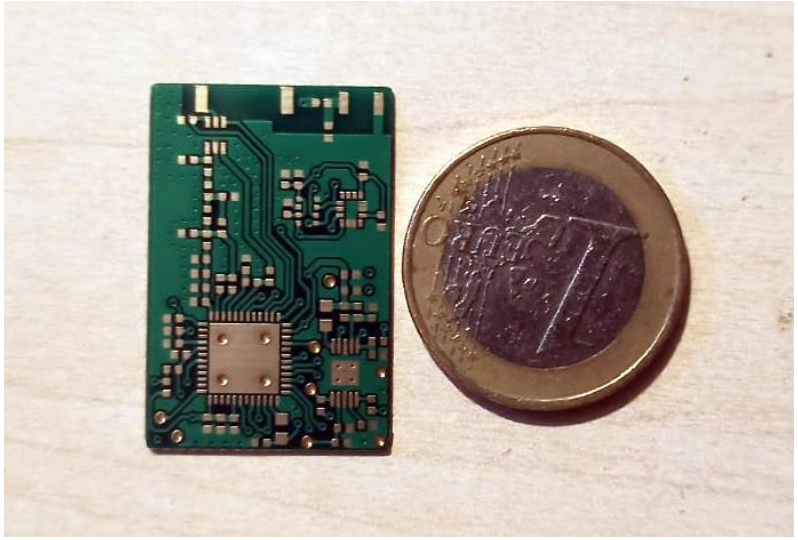




The falcon project

A miniaturized, ultra low weight **sensor node** to track birds

- Weight - as low as 8g
- Energy harvesting using solar cells
- LoRa based communication using Things Network
- Low power GPS and IMU including accelerometer, gyroscope and barometer



Experiment

Peregrines at TU Delft

Peregrines at ASML

Peregrine falcons at ASML Tower, Veldhoven

Birds Nest

Birds View

Images are automatically updated every 7 seconds

Cool Facts

- The name "peregrine" means wanderer, and the Peregrine Falcon has one of the longest migrations of any bird, as much as 25,000 km (15,000 mi) in a year. They are present in all continents except Antarctica, and on many oceanic islands.
- The Peregrine Falcon is the fastest animal on earth, able to reach speeds of up to 320 km/h (200 mph) as it drops toward its prey.
- In the Netherlands, Peregrine Falcons arrive in the autumn from Scandinavia and return north again in March. Sometimes, young birds will stay behind and may even nest here if they can find a suitable nesting location. As cliff breeders, they have adopted tall buildings as an alternative. There are about meanwhile 30 breeding pairs in the Netherlands.
- In late 2009, a young male bird used ASML building 8 as his wintering location. ASML therefore decided to provide a nest box on the roof of building 8, which was occupied by a pair of Peregrine Falcons in April 2010. They stayed all year and laid 4 eggs in March 2011.

Measurements

The male is much smaller than the female.
Typical sizes are:

Length 36–49 cm
Wingspan 100–110 cm
Weight 530–1600 g

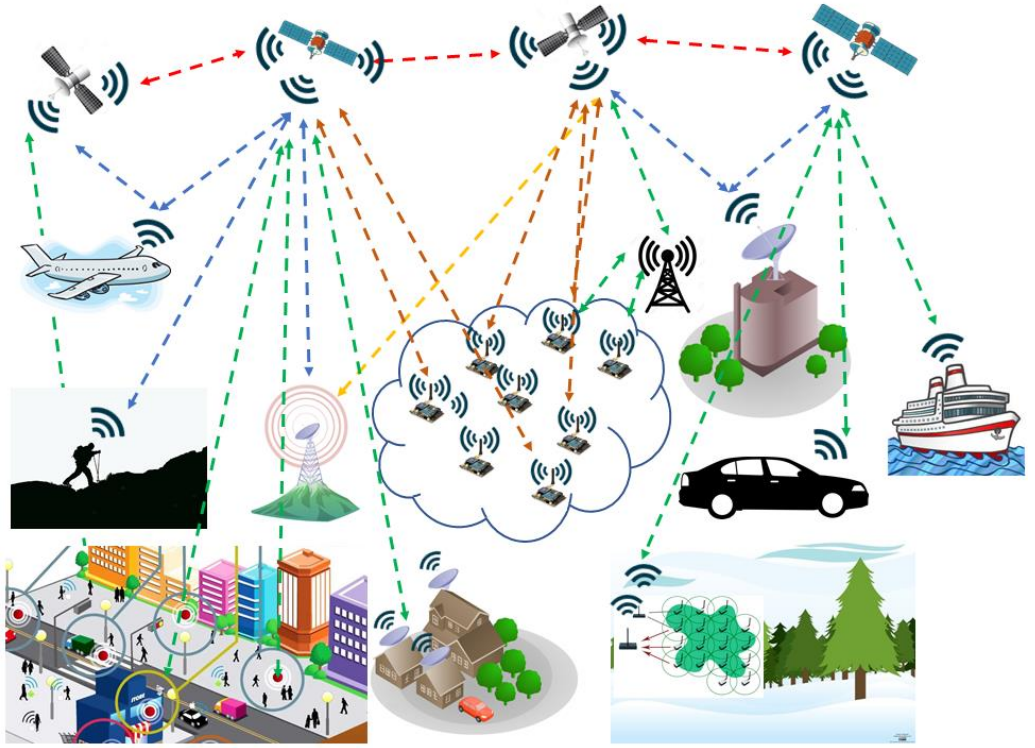
Other Names

- Slechtvalk (Dutch)
- Faucon pèlerin (French)
- Halcón peregrino (Spanish)

https://asml.peregrines.nl/

Space IoT

- **Space IoT -** a game changer for the future of IoT
- **Global network coverage** using satellite communication
- **Millions** of IoT nodes and gateways directly anywhere on Earth – cities/villages, mountains, oceans, forests – at the same time



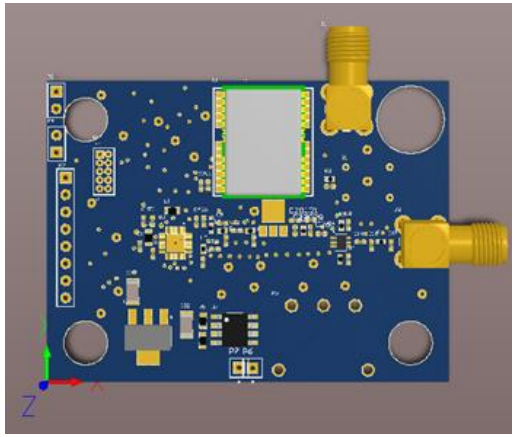
Satellite based messaging system

Space IoT

- **Emergencies** such as earthquakes, cyclones, and tsunamis -> payload on satellite alerts multiple sensor nodes carried by fishermen, soldiers, or mountaineers.

- **Rescue operations** – Sensor nodes can send messages including information about their location to the satellite directly using
  (i) Android mobile (over Bluetooth/WiFi)
  (ii) USB Keypads

- **Miniaturized** low power modules with two way communication



Transceiver on the satellite

Sensor node on ground

Reach Out

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Zero Energy Development

Are you ready to be amaZED?

Join the batteryless revolution!