Fraunhofer IIS

Fraunhofer Institute for Integrated Circuits IIS

Wildlife Research and Nature Conservation with AI and satellite-based IoT Technology

TS-UNB/mioty® for Satellite IoT Systems

Florian Leschka, Fraunhofer IIS, Germany
Department RF and SatCom Systems
08/07/2024, Les Journées LPWAN '24 Conference
Pau, France

mioty

01

Introduction to Fraunhofer Society and Fraunhofer IIS

The Fraunhofer-Gesellschaft

At a glance

Mission: Applied research

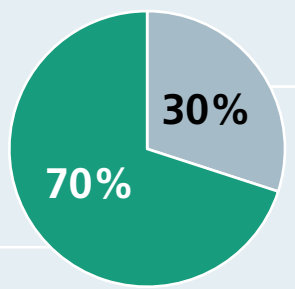
Applied research focusing on key future-relevant technologies and the commercialization of findings in business and industry. A trailblazer and trendsetter in innovative developments.

> 30,800 employees

76 institutes and research units

€ 3.0 billion business volume
€ 2.6 billion contract research

Industrial contracts and publicly-funded research projects



Base funding from Germany's federal and state governments

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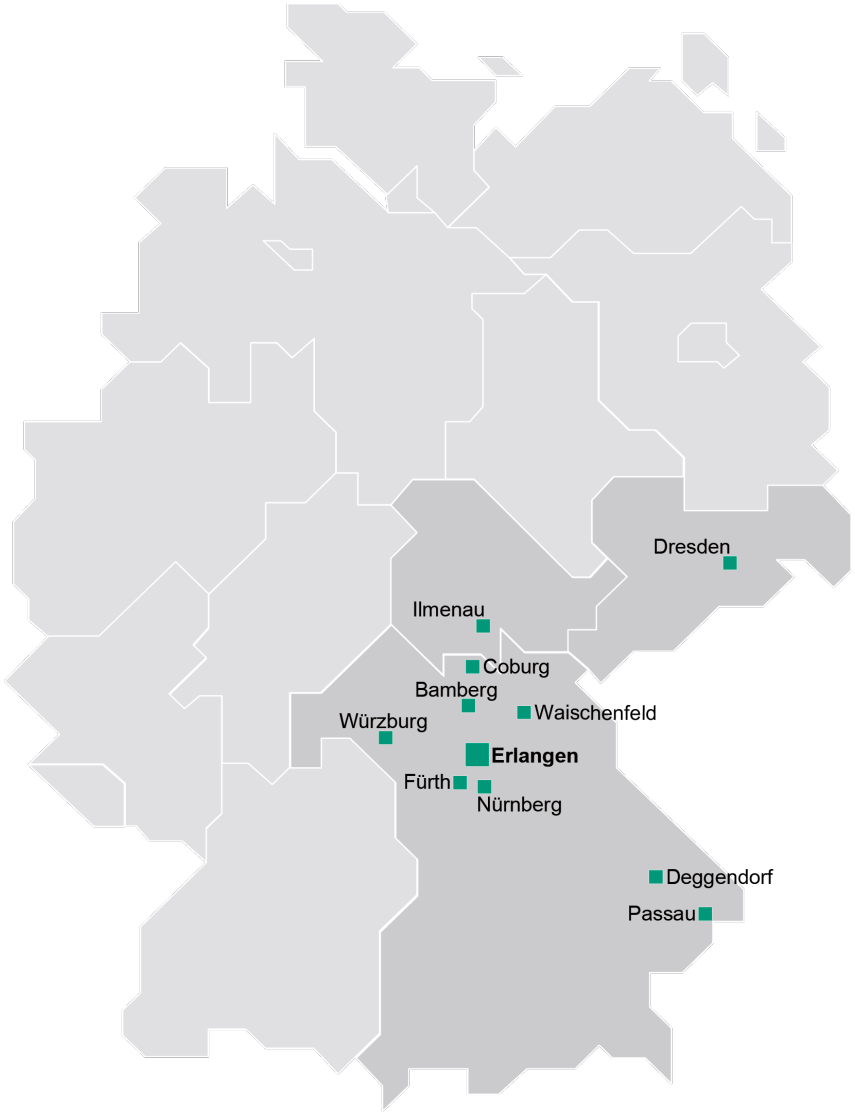
Fraunhofer Institute for Integrated Circuits IIS

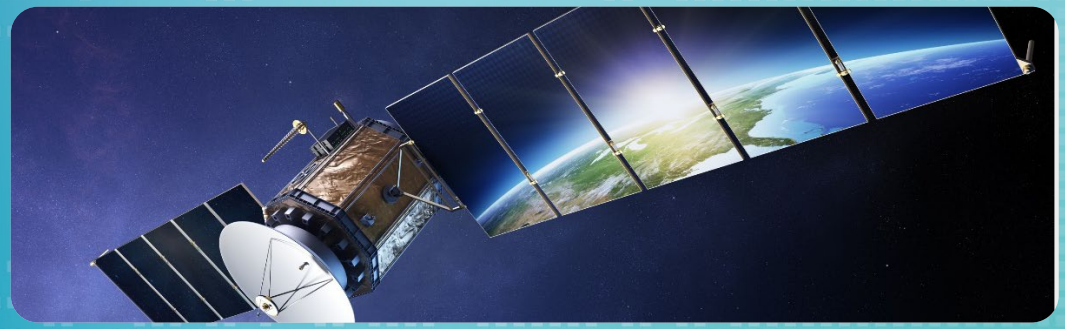
Introducing the institute

Fraunhofer Institute for Integrated Circuits IIS

- Founded: 1985
- Largest of 76 Fraunhofer institutes
- Over 1100 employees
- Budget of approx. 200 Mio EUR per year
- Applied research institute

- Non-profit organization
- Mostly financing based on (industry) projects
- Headquarters in Erlangen
- 15 more sites in Germany





We develop solutions for satellite communications and customized antenna systems to connect people and things everywhere.

Our Mission,
Department RF & SatCom Systems

02

GAIA-Initiative

gaia-initiative.org

GAIA
INITIATIVE

GAIA-Initiative

Wildlife Research and Conservation with AI and satellite-based IoT Technology

Fraunhofer IIS, Erlangen
Department RF and Satellite Systems

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

Fraunhofer IIS
Fraunhofer-Institut für Integrierte Schaltungen IIS

Leibniz-Institut für Zoo- und Wildtierforschung
IM FORSCHUNGSVERBUND BERLIN E.V.

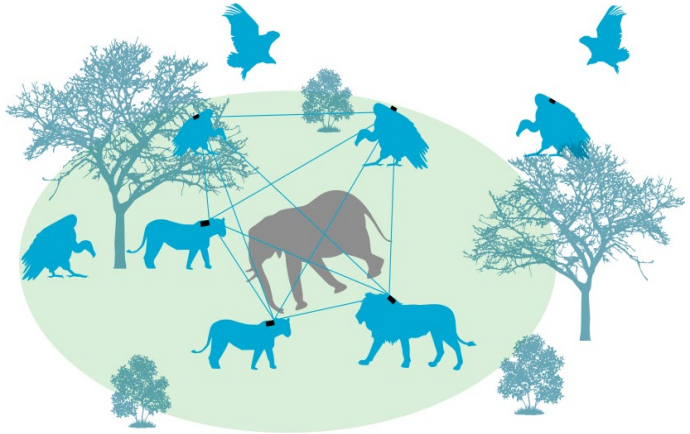
RAPID CUBES

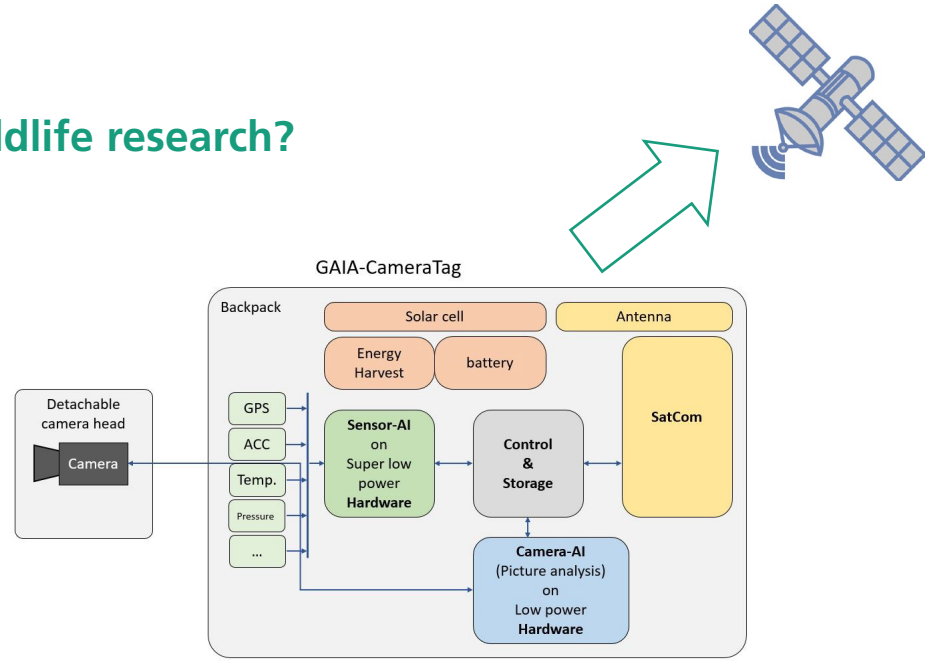
DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

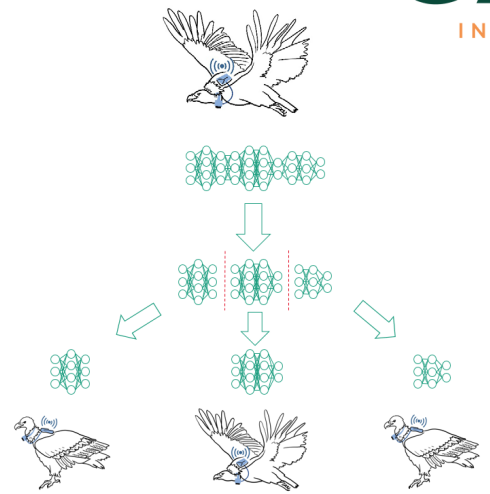
Wildlife monitoring with cameras, sensor-based AI and satellites

Motivation

How does Fraunhofer IIS support wildlife research?







Biologist meets Engineer

We are researching new technological aspects in close cooperation with biologists when networking intelligence. We focus on energy-efficient solutions.

AI Camera tag Development & Satellite Communications

We are investigating possibilities for extensive wildlife monitoring via satellite by connecting the animal directly to compact, low-cost transmitters.

Distributed Computing & AI

We link animals with each other for joint distributed AI-supported computing with large data sets. The animals form a local ad-hoc network with volatile participants.

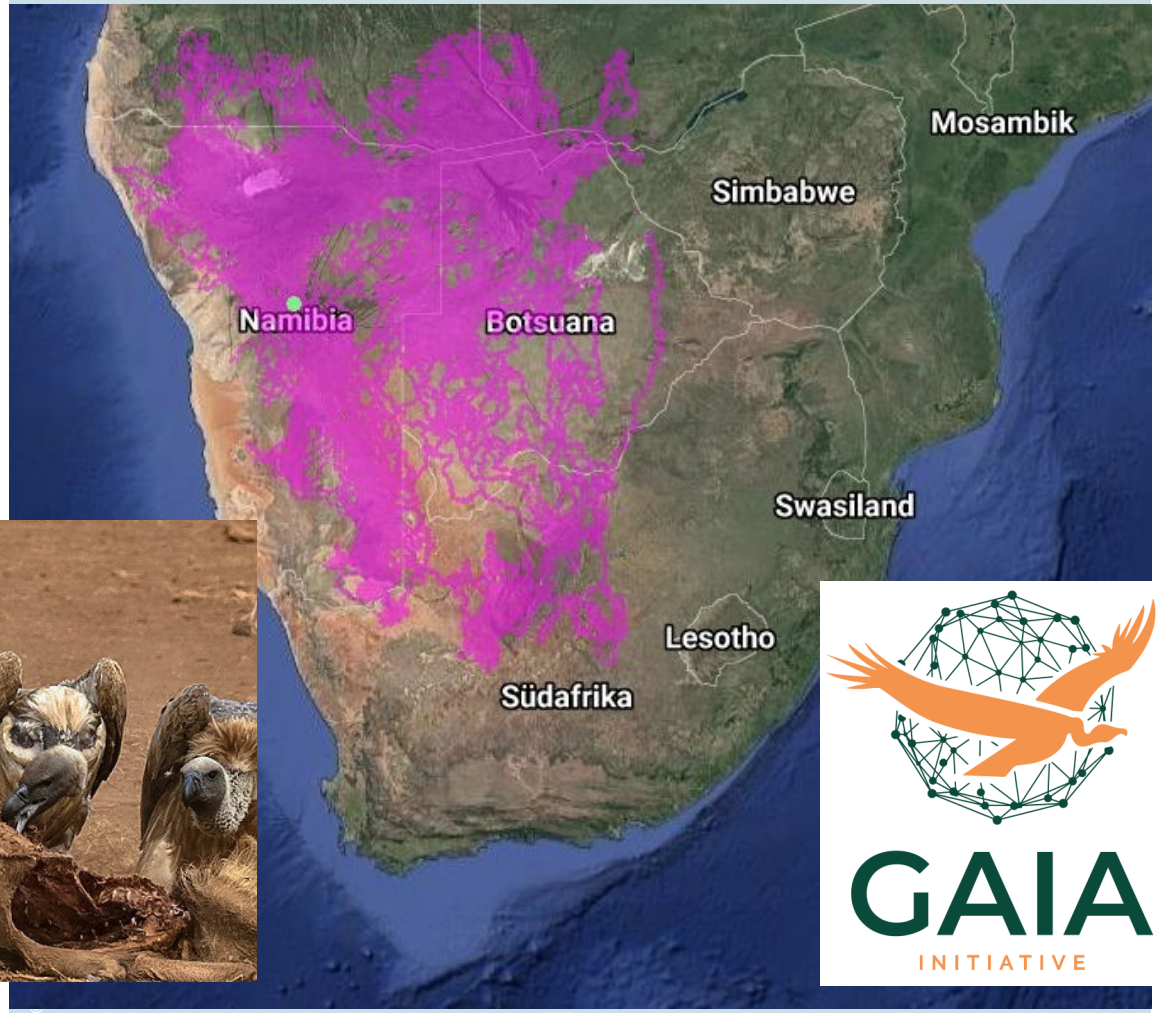
Wildlife Research and Nature Conservation with AI and Satellite IoT Technology

Research of and with vultures

Why vultures?

- Little researched
- The vultures' swarm intelligence (discovering carcasses) can deliver important information on mass animal deaths e.g. due to diseases
- Movement profile covers a large area

Movement Profile of tagged vultures in Africa



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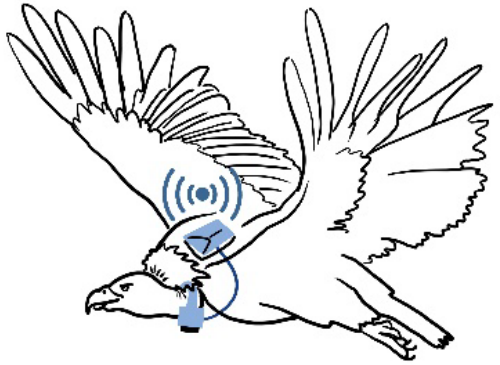

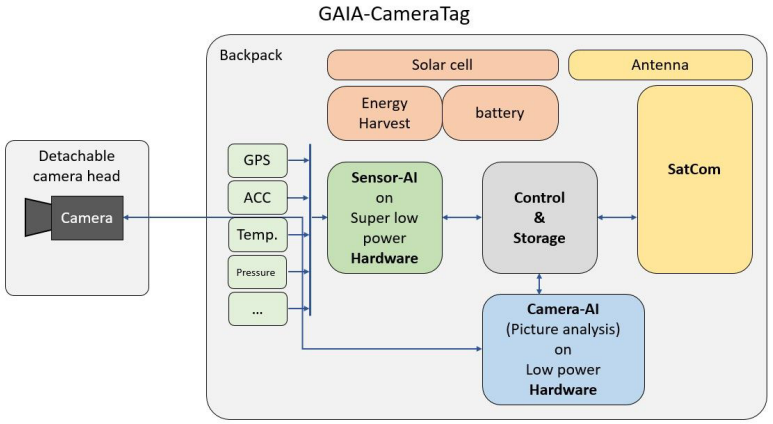

GAIA
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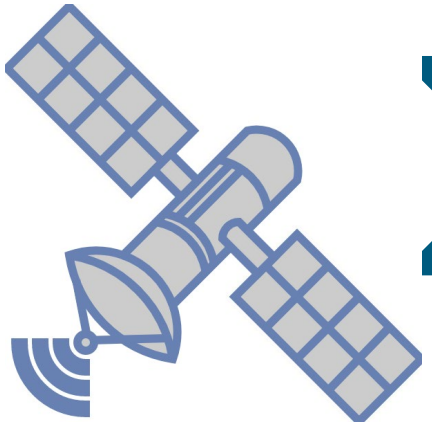
Vulture approaches dead animal and eats

AI evaluation of the acceleration data triggers camera

Camera captures image

Onboard AI classifies alarm status

mioty®-SatCom module transmits alarm



LEO satellite receives data

Data is forwarded to ground station

Automatic data processing

User (biologist) analyzes data

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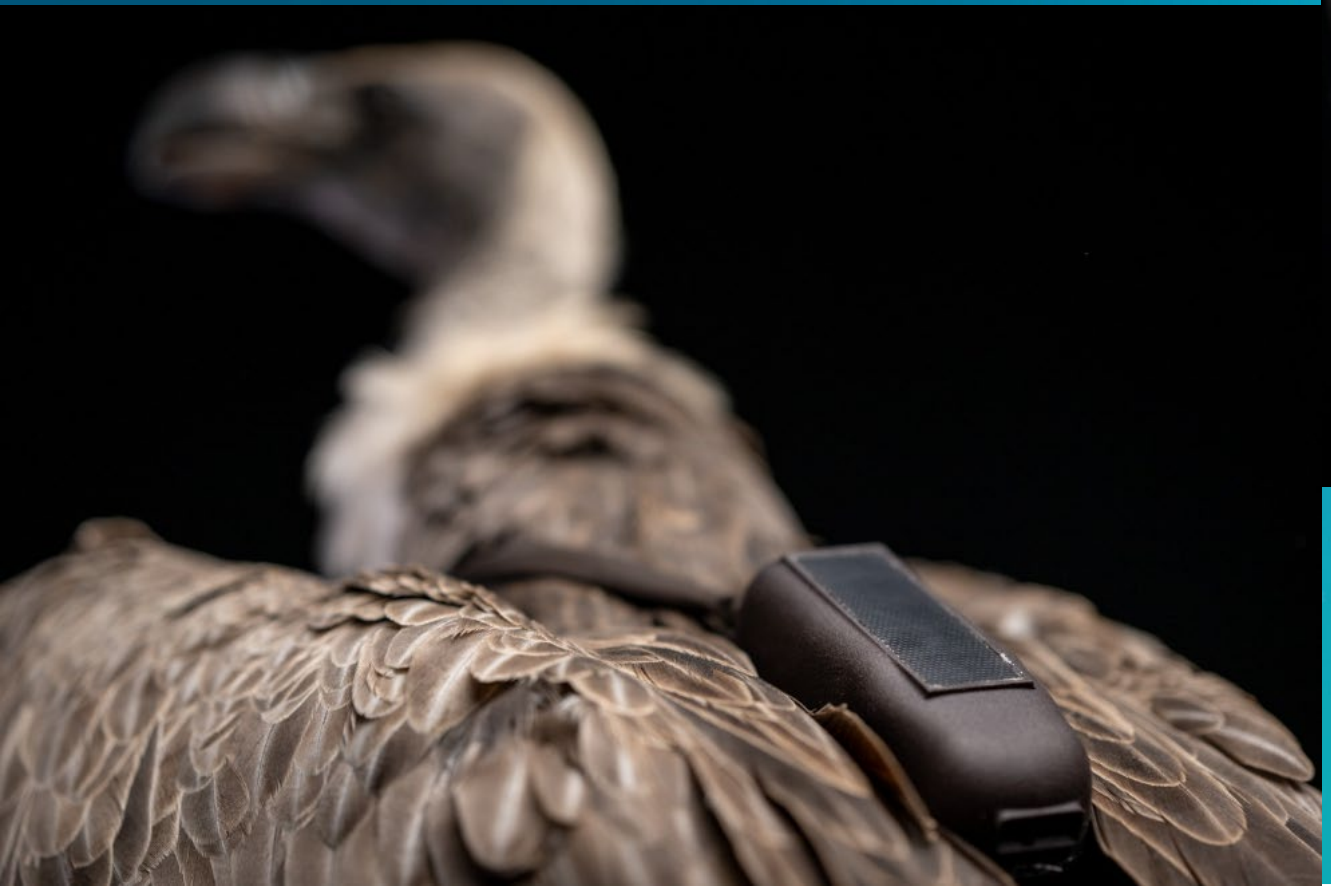
Tag-Hardware



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GAIA-Sat-IoT / SyNaKI (part of GAIA-Initiative)

Developments of mioty® technology for SatCom Scenario

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages
DLR Deutsches Zentrum für Luft- und Raumfahrt
Raumfahrtmanagement

GAIA INITIATIVE

Jan 2022 - Jun/Dec 2024

GAIA-Sat-IoT: Guardian of the wild using Artifical Intelligence Applications and Satellite based IoT Networks

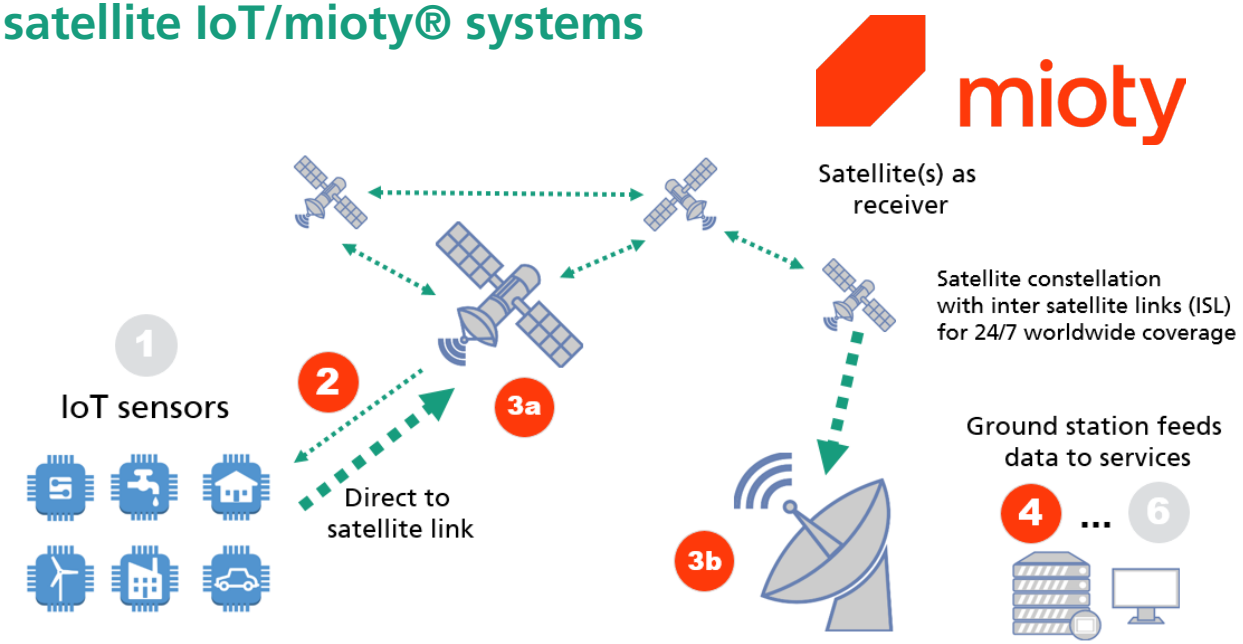
SyNaKI: Synergie natürlicher und künstlicher Intelligenz im Schwarm (Synergy of natural and artificial intelligence in a swarm)

Development of single components for future LEO satellite IoT/mioty® systems

Our key aspect of both projects:

- Higher data rate for mioty®
- Bigger message size for mioty®
- Bi-directional communication for mioty® satcom sensor tags
- Tag development for S- and L-Band
- Enhanced Doppler compensation (*)
- Receiver architecture for distributed LEO constellation
- **Prepare mioty® technology for LEO satellite mission**

(*) based on patented ideas



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Next Step: GAIA-MISSION

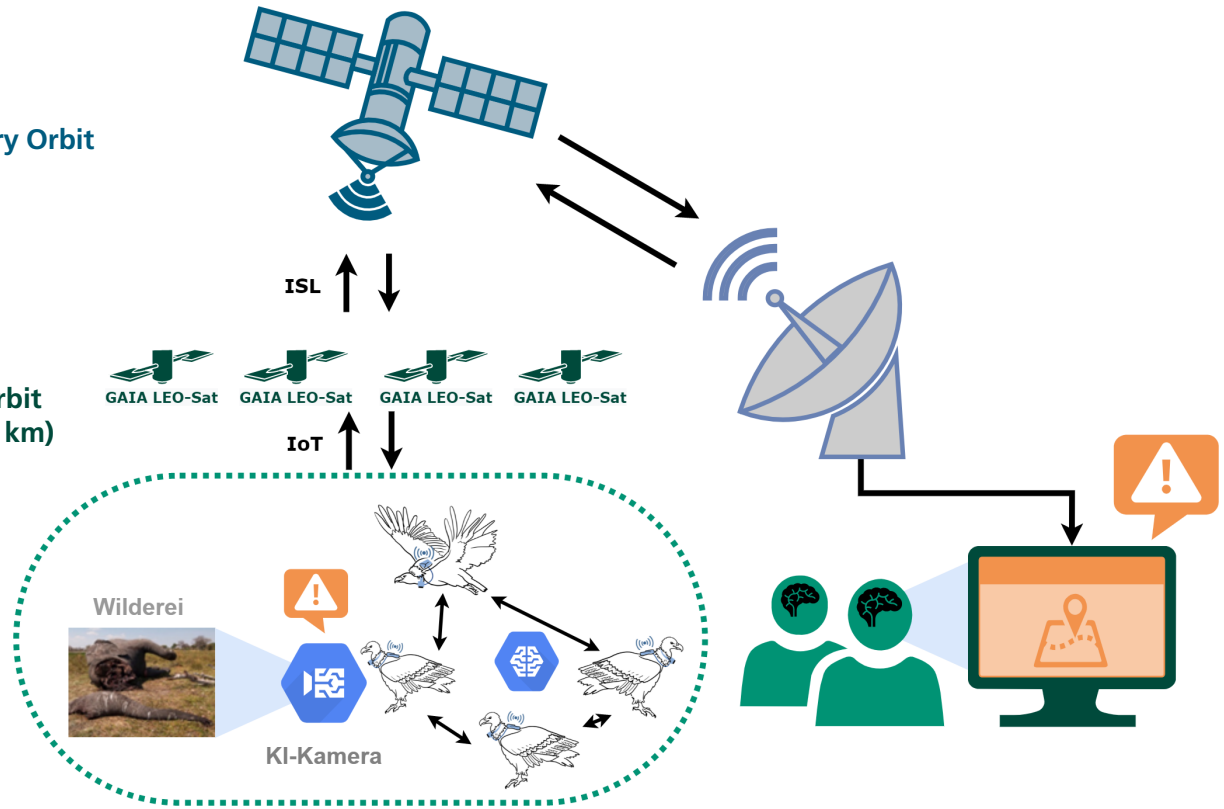
GAIA
MISSION TO DEVELOP AND INTEGRATE SMART TAGS AND SATELLITES INTO INTELLIGENT OBSERVATIONAL NETWORKS

GAIA INITIATIVE

Mission for In-Orbit-Verification of recently developed Technologies und for Demonstration of Applications

GEO
(Geostationary Orbit at 36000km)

LEO
(Low Earth Orbit at up to 1500 km)



03

mioty® - our (Sat) IoT Solution

mioty®

Terrestrial IoT Solution of Fraunhofer IIS

- IoT technology: Long history at IIS („Smart Metering“)
  - TS-UNB/mioty®
- LPWAN system (terrestrial) up to 30 km
- TS-UNB → ETSI standard TS103357
- ALOHA based access technology
- Telemetry data transmission
  (10-245 Bytes per telegram)
- Supporting bidirectional communication
- ISM frequencies: e.g. 868/915 MHz [EU/US]
- Small bandwidth (typ. 200 kHz)
- Up to 3.6 million messages/day @ PER <1%
- Low computing power for receiving and decoding possible (e.g. based on Raspberry Pi 4)
- Energy efficient sensor nodes
- Low-cost devices (COTS, multi source)
- mioty™ alliance established in 2020 (mioty-alliance.com)

mioty alliance

mioty® / TS-UNB
Details

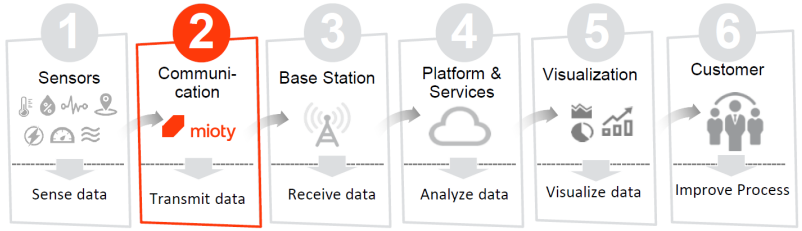
Telegram splitting & code rate 1/3

- Robust against in-band interference
- High capacity → massive number of devices
- High energy efficiency → long lifetime

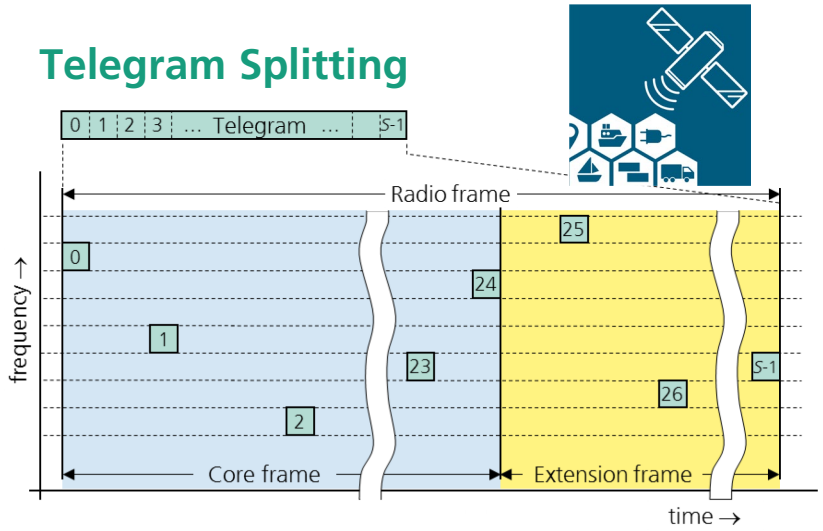
COTS parts / SDR platform (multi source) → low cost sensor nodes

mioty alliance

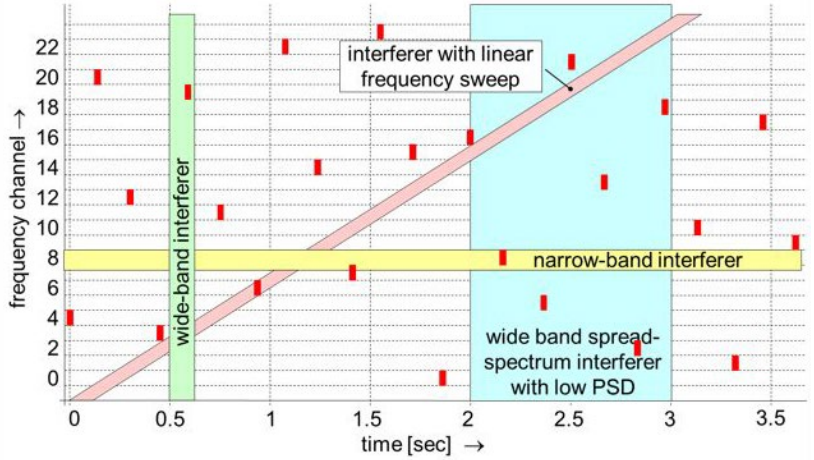
Entire value chain available: System development, incl. sensor connectivity, gateway, cloud service etc.



Telegram Splitting



Interference Scenarios



High market readiness incl. industrial cooperation

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From Terrestrial to Satellite IoT

Why mioty® for satellite IoT networks?

KPI System Capacity:
3.6M Messages/day/200kHz/beam

Multi-source transceiver hardware

Energy efficiency
Long battery lifetime of nodes

Low-cost nodes

High market readiness, entire value chain available → mioty® alliance

Easily adaptable & scalable to specific satellite scenarios

LPWAN protocol with highest system capacity
→ mioty® for large roll-outs
See mioty® comparison study by TU Ilmenau (on next slides);

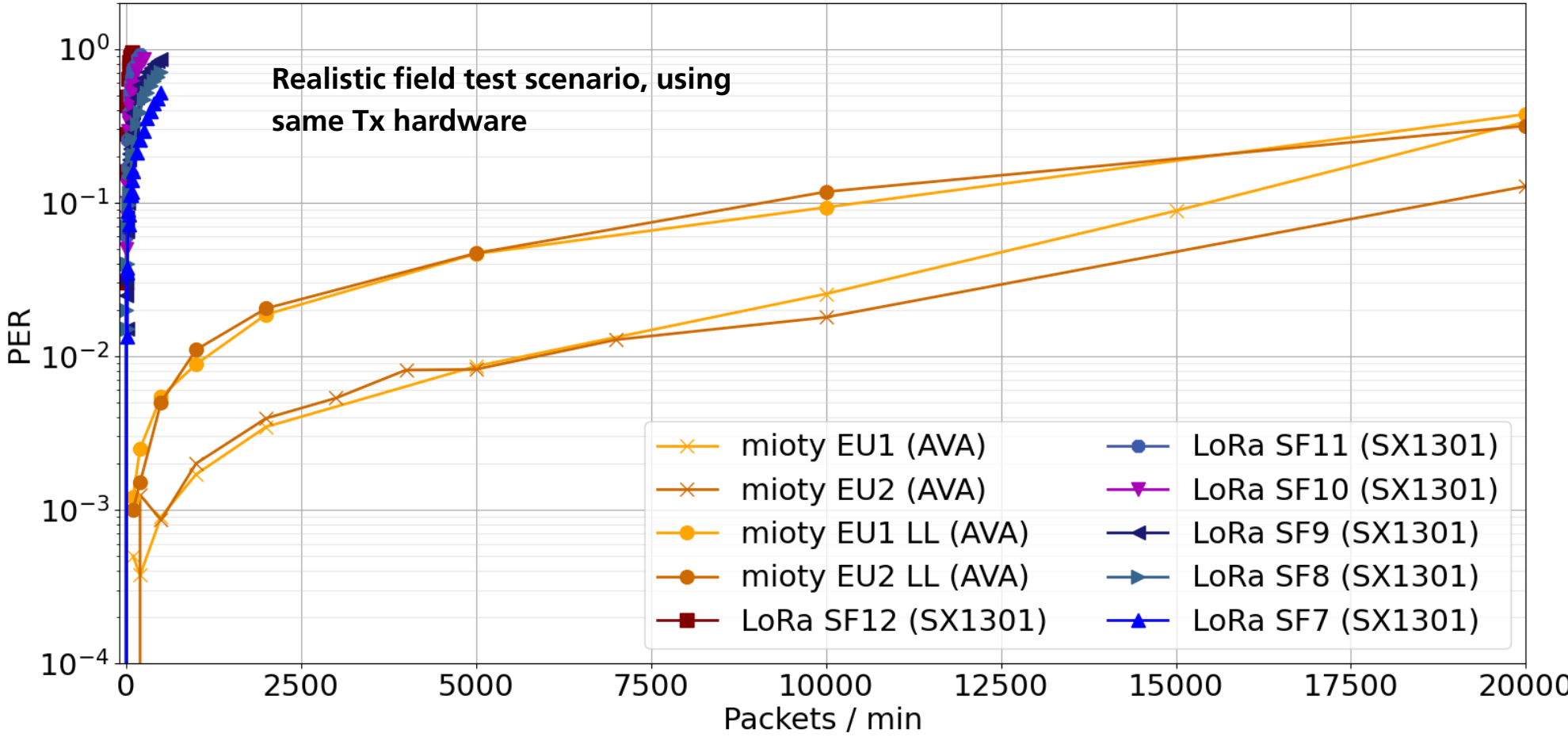
Robust against Doppler and interference
Developed in ESA and DLR projects

Open ETSI standard
TS-UNB, vendor independent

mioty® Comparative Study Report (mioty® vs LoRa) by TU Ilmenau

System Capacity as KPI

Reference: https://mioty-alliance.com/mioty-vs-lora-study-report/



mioty® is suitable for large roll-outs

Realistic Field Test scenario → Do not trust field trial results with few devices

mioty® Comparative Study Report (mioty® vs LoRa) by TU Ilmenau

mioty® vs LoRa/ LoRa-FHSS

Recently released: mioty® vs LoRa-FHSS

Reference: https://mioty-alliance.com/mioty-vs-lora-study-report/

Key Points of updated study

- LoRa-FHSS significantly increases the capacity wrt. classical LoRa
- Energy consumption is 40% higher than LoRa SF12 (making it 6 times more power hungry than mioty®!)
- Sensitivity goes down 3dB in comparison with LoRa SF12 (lowering the range)
- Transmission and on-air time goes up (limiting the no of messages allowed to send within the duty cycle limitations)
- The header bursts are not robust, making LoRa FH-SS vulnerable to noise, especially classical LoRa
- LoRa FHSS still relies on classical LoRa for the downlink

04

Key Takeaways & Outlook

Key Takeaways and Outlook

Our Offer:

Fraunhofer IIS supports national and international SatCom players in:

- **Consulting**
- **R&D in SatCom**
- **System Design**
- **System Simulations**
- **Constellation Design**
- **Test & Verification**

1. **GAIA-Initiative**: **developing a new generation of animal tags** equipped with on-board artificial intelligence (AI) & camera and **satellite-based IoT communication** technology
2. **System Capacity is key feature** for successful SatCom **business cases**
3. **TS-UNB/mioty® outperforms IoT/LPWAN protocol competitors**
4. **Trends in IoT: AI, Distributed Computing & Satellite Swarms**

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- Fraunhofer IIS Satellite IoT https://www.iis.fraunhofer.de/en/ff/kom/satkom/satellite_iot.html
- GAIA-Initiative https://www.gaia-initiative.org
- GAIA Sat-IoT http://gaia-sat-iot.de
- SyNaKI http://synaki.de
- mioty® Alliance http://mioty-alliance.com/
- Mioty® vs LoRa study report https://mioty-alliance.com/mioty-vs-lora-study-report/
- Paper „Time Variant Doppler Compensation for TS-UNB" https://ieeexplore.ieee.org/document/10192999
- Paper "Doppler Localisation of TS-UNB IoT Nodes from LEO satellites" https://ieeexplore.ieee.org/document/10572039