

IoT for Earth Observation - Motivation & Logic

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ESTEC, 16 Feb. 2023 - **IoT4EO 2023 Workshop**



Devising Earth Observation Missions

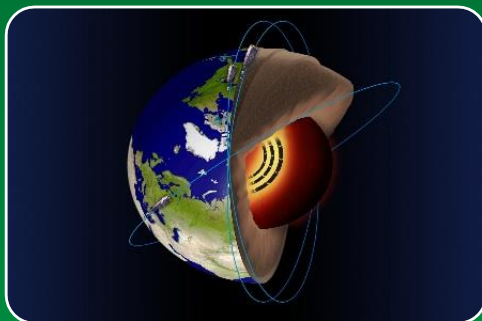
Overall Guiding Feature: User Driven (Living Planet Program)

Research Missions

Member States

Earth Explorers
& Scouts

Ideas from science partners
in MS (Open Calls)



Also Mission of Opportunity
with partners outside MS

Earth Watch Missions



Copernicus



Meteorology



InCubed



Member States

Other

Altius
TRUTHS
Arctic Weather Sat
PNRR

- User needs from institutional partners & industry

- Mission definition by ESA with industry, partners & users

Growing
diversity

vision.esa.int

5 ESA PRIORITIES FOR 2025



Strengthen ESA–EU relations



Boost commercialisation for a green and digital Europe



Strengthen space for safety and security



Address programme challenges



Complete the ESA transformation

IoT as enabler for EO (near permanent-connectivity & simplicity)

- **TIMING** is very important
 - Faster tasking of EO sats + faster delivery of actionable information
- More **EFFICIENCY** (autonomy , federation of heterogenous systems)
→ growth to constellations (also commercial EO, not just institutional)

Need for near-permanent contact with LEO sats

Near-permanent connectivity

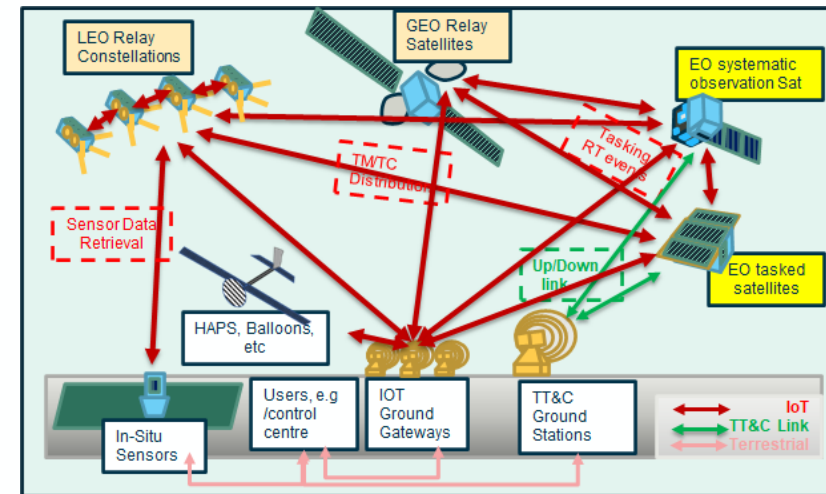
- Low latency is the key driver (not data rate)
- Scale needed: enough number of nodes and routing sites:
 - worldwide effort → via GEO, LEO IoT constellations, ground gateways all over the planet
 - multiple providers → Standardisation of Physical & Data Layer + Open Protocols, incl. Security
 - It might take long? What about now?
 - Inter Operational Agencies Group (IOAG) will try to help
- Cost to operate 24/7 challenging

Seamless communications & Simplicity → No steering of antenna or satellite

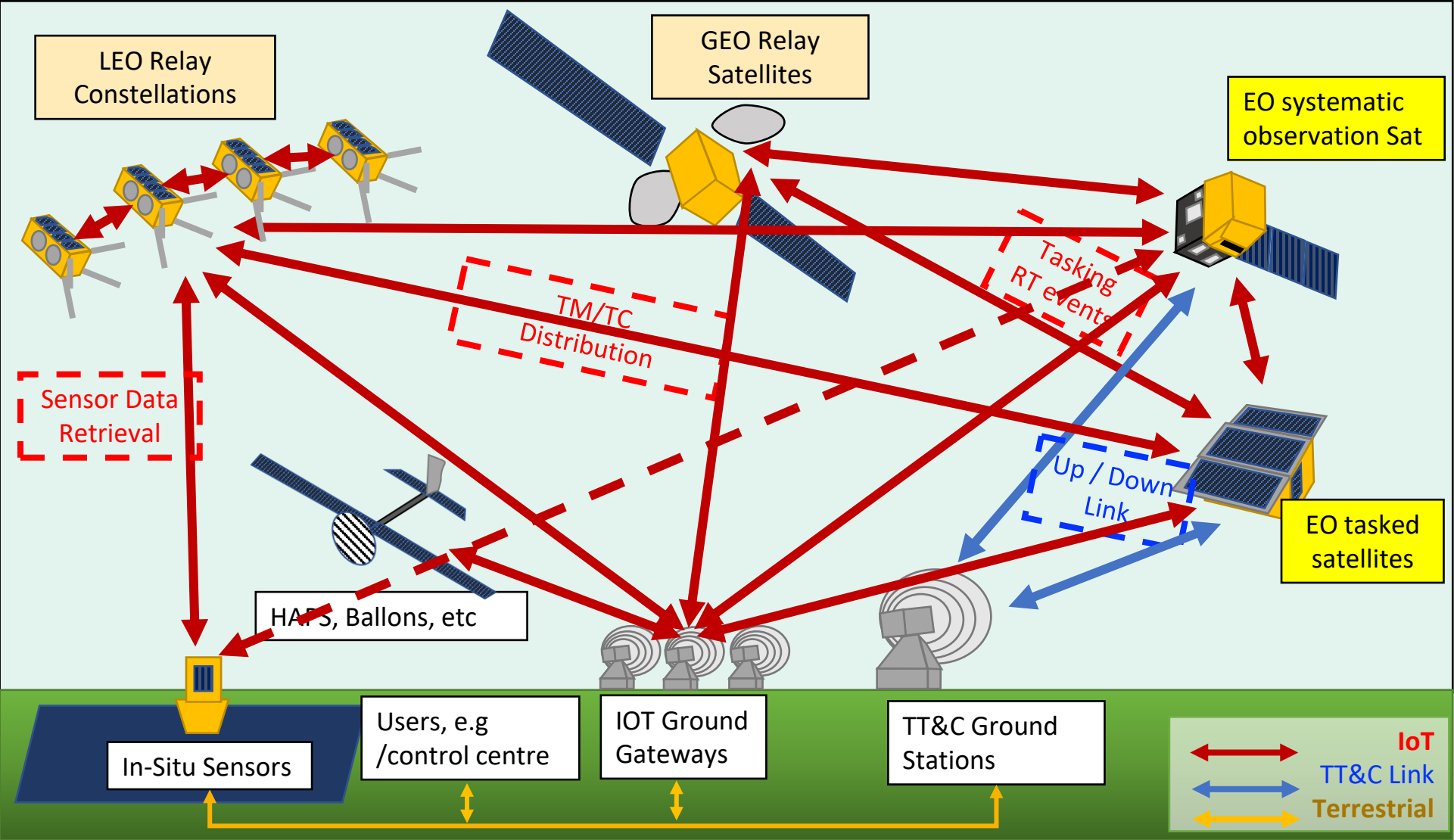
- Low C/No → Not targeting high data rates
- LEO satellite = one/many IP node(s) - (part of a larger network)
 - but perhaps other options (e.g. messaging)

Application of low data rate – permanent connectivity

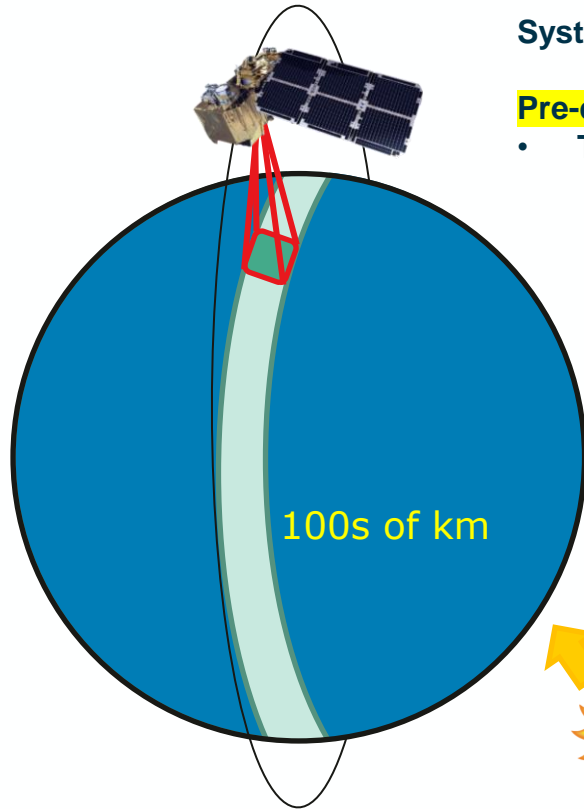
- e.g. commanding, basic handshake, thumbnails/event coordinates
- complement (not a replacement) to classical TC links (can be different channels / freq.)
- Institutional & NewSpace : IoT as federator



EO Use cases - Concepts for the use of IOT in EO



Carpet mapping



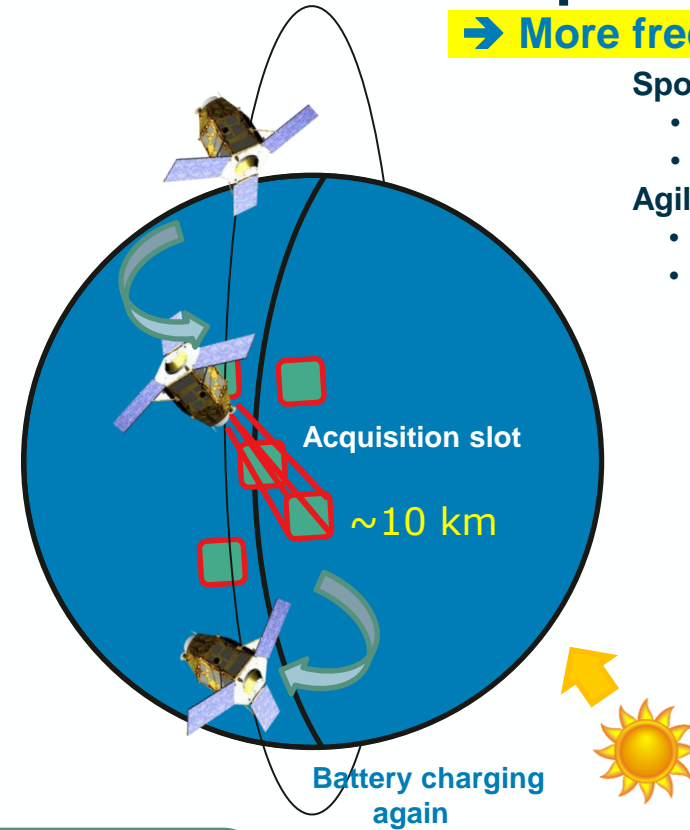
Systematic coverage

Pre-determined acquisitions

- Today uplinked 1x / day (in ~10 min slot)

On-demand acquisition with SmallSat

→ More frequent tasking



Spotlight / focused acquisition

- reduced Field of Regard
- High spatial resolution

Agility needed

- Quick re-planning
- Pointing - ADCS

Many New applications combining Traditional & SmallSats

- Agriculture: VHR complement to Sentinel-2
- GHG (CO₂,CH₄,NO₂): complement to CO₂M
- Detection of events: fire, ships, gas leaks, ...
- Others (e.g. security)

Timeliness & Simplicity is key
IoT could be the enabler

What **IOAG** IoT Study Group (IoT4EO) would like to do?

InterAgency Operations Advisory Group – [IOAG link](#)

IOAG – worldwide reach

IOAG SG can give **recommendations** to [IOAG External Groups](#) such as:

- **CCSDS**: Consultive Committee for Space Data **Standards**
- **SFCG** : Space **Frequency** Coordination Group

But before, we need to document → raise worldwide (multi-Agency) awareness → standardise accordingly

- Inspired by the positive LEO26SG experience (https://www.ioag.org/Public%20Documents/2019-02-22_LEO26SG_Report_Final.pdf)
- Its **content** is :
 - **purpose** and motivation - “going federated”
 - **Concept of operations**
 - **Mission** and **Business cases** (Institutional, NewSpace, EO cases, etc.)
 - **Network** and **Architecture** considerations
 - **Technology** challenges
 - **Standards** and Regulatory status: e.g. Terrestrial and IoT for space , ...
 - **Appendixes**: e.g. link budgets, standards, **inventory** details - for more technical details

IOAG MEMBERS



IOAG OBSERVERS



Audience for the Study Group Outputs:

1. Flight Missions and Program Offices
2. Infrastructure/Service Providers
3. Standards and Technology Implementers

Approach:

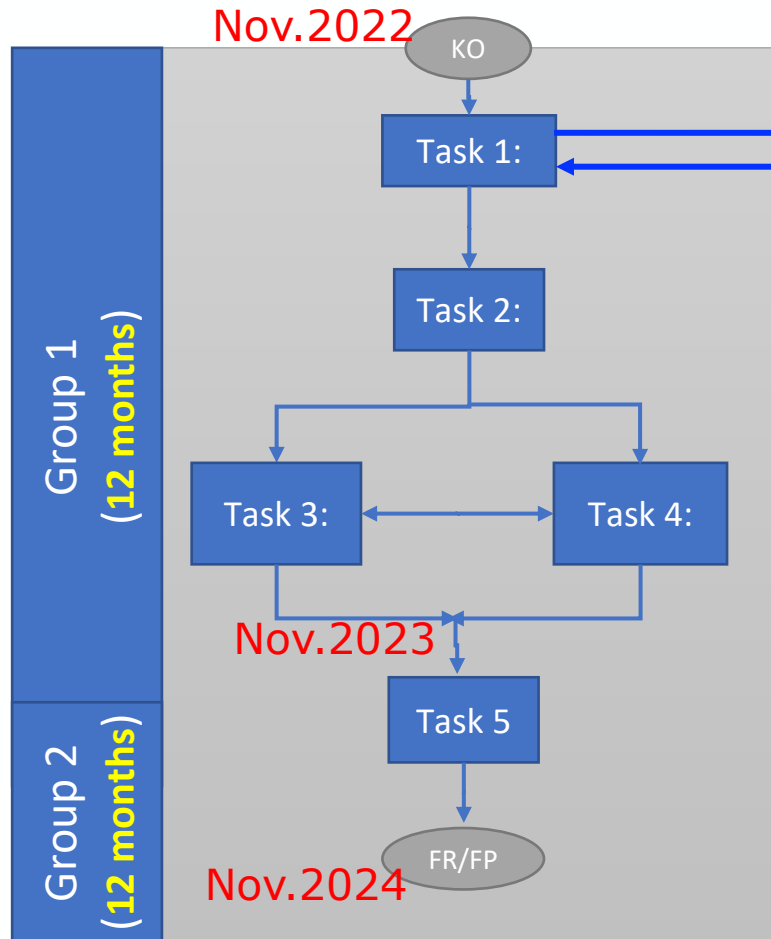
1. Develop **High-level Concepts of Operations** and **Business Cases** for IoT comms between LEO spacecraft and ground comms, supported by relay infrastructure where relevant.
 - Summarize Agencies objectives for the use of IoT space-Earth, Space-Space and Earth-Space bands
 - Define a standardized approach to use IoT to achieve interoperability
 - Collect information: existing flight mission and ground assets, incl. gateways
2. Identify **preliminary Architecture**, incl. **comms protocols, security needs** and relevant **Interfaces**
 - IoT reference elements: e.g. RF, modulation, coding, comms-protocols, security needs, interface methods, ...
 - Define architectural elements.
3. Identify **Standards, Models** and **Technology Development Needs**
 - Assess application of existing + forthcoming CCSDS and IoT standards
 - Planned flight mission, relay and ground assets.
 - Assess TRL for IoT system elements → Identify technology needs & roadmaps.
 - IoT services and frequencies in use → consider evolution and **possible recommendations to ITU**.

Initial Members in IOAG IoT4EO		Delegation
Audouy	Claude	CNES
De Cola	Tomaso	DLR
Ewald	Ralf	
Clazzer	Federico	
<i>Gnat</i>	<i>Marcin</i>	
Stuglik	Szymon	ESA
George	Steven	
<i>Rosello</i>	<i>Josep</i>	
Reggestad	Vemund	
Zeppenfeldt	Frank	NASA
Connerton	Robert	
Hodge	Angela	
Le Moigne-Stewart	Jacquiline	

2 parallel ESA studies kicked Off in Dec.2022 → ESA input to IoT4EO SG

SoW ([link](#)) – 2 studies granted

- one OHB (DE)
- one Airbus (FR)



Workshop
16-17 Feb 2023

<https://indico.esa.int/event/438>

3 year scenario

- Use what available

7 year scenario

- Optimise,
- go to ITU WRC if necessary

Workshop
End 2023 – Beg. 2024

Work descriptions

T1: Use cases, Market Survey and Requirements review

- Workshop on 16th Feb. 2023

T2: ConOps and Architecture Definition – Two Labeled scenarios :

- 3-years – use services as available
- 7-years – consider optimal setup

T3: Detailed architectural design, including simulations

- link budgets
- Orbit propagators (system)

T4: Technology/Standardization Roadmap and IOAG draft report

- Pre-development of modules (in future activities)
- Taking action in WRC-2027 for freq. ?

T5: Support to ESA for international exchange

- With IOAG Agencies + NewSpace (via Workshop or other)

Appendices of SoW 1-11286 (link) :

A. High Level Definitions

B. Initial EO Use Cases

C. High-level Requirements

D. Minimum set of scenarios to simulate at System Level

- Ubiquitous comms to LEO Earth Observation sats
 - Timeliness & Simplicity: useful even at kb/s ?
 - How to reach the required scale ?
- Many unknowns → Concepts for the use of IOT in EO activity
 - e.g. data rates , regulatory services
 - 3 – 7 years “labelled” scenarios → how similar will they be ?
- Workshop 16-17 Feb. 2023 as 1st step → also chance to network
- How can you contribute ? (presentations + discussion tomorrow)
 - Are we taking the right assumptions (simplicity vs data rates)
 - What EO use cases ? (at kb/s)
 - Is near permanent connectivity to LEO sats feasible : are today services sufficient ? evolution needed ?