Φ-lab

esa

The ESA Φ-lab

Science, Applications & Climate Department
Directorate of Earth Observation Programmes

We strongly believe in
truly transformative ideas and in
the power of compelling partnerships
to accelerate the Earth Observation future

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European Space Agency

The ESA Φ-lab – What ?

Φ-lab
innovate and apply
under-one-roof

Accelerate the future of Earth Observation

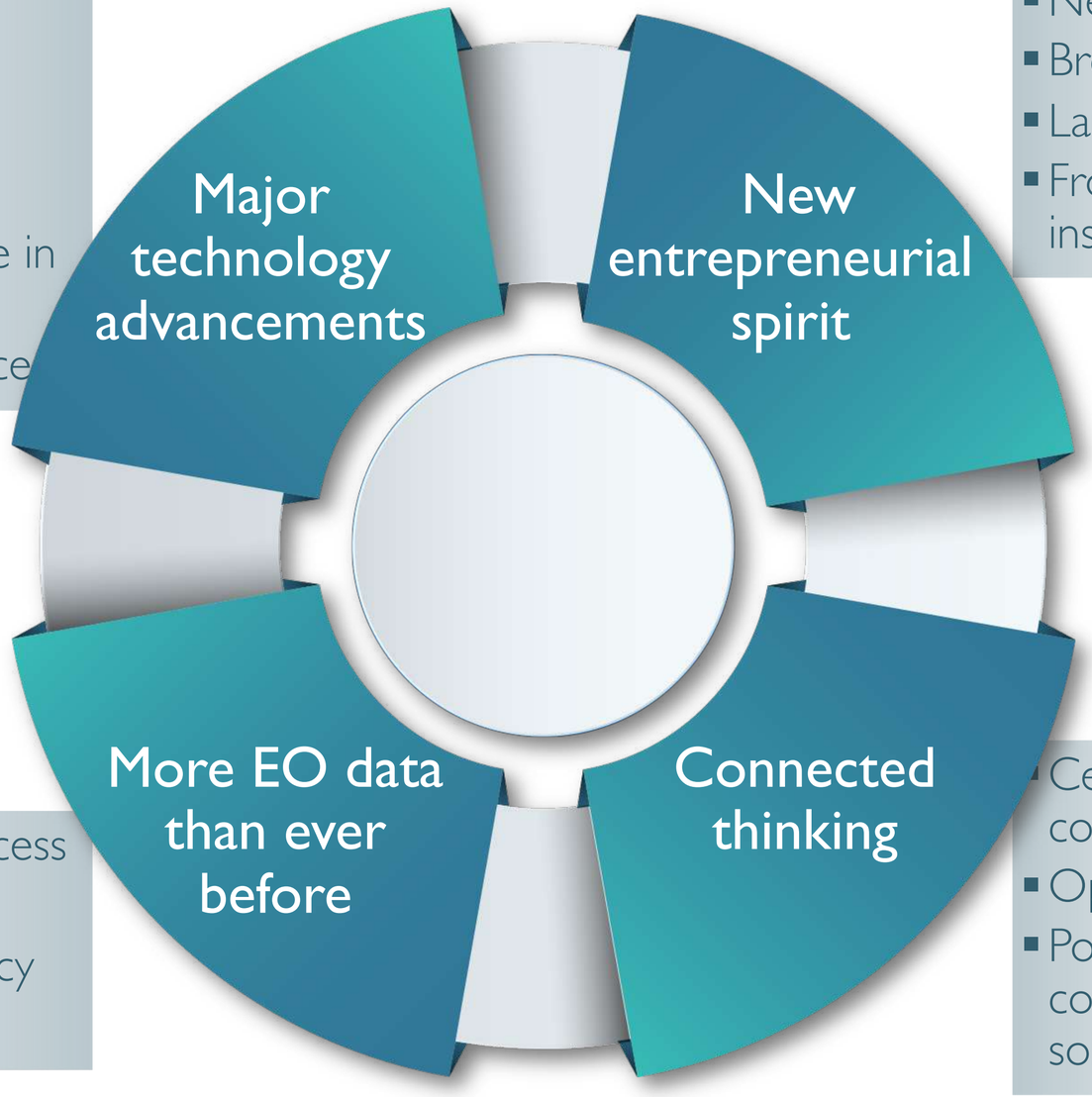
via transformational innovation*

strengthening Europe's world-leading competitiveness

*transformational innovation: with the ability to completely transform or create entire industries via new technologies

The Earth Observation perfect storm

- Lower access to space costs
- Smart sensors, better performance, lower SWaP-C
- Commercial constellations
- Cloud computing
- Huge computational power available in space
- Artificial Intelligence and IOT in space

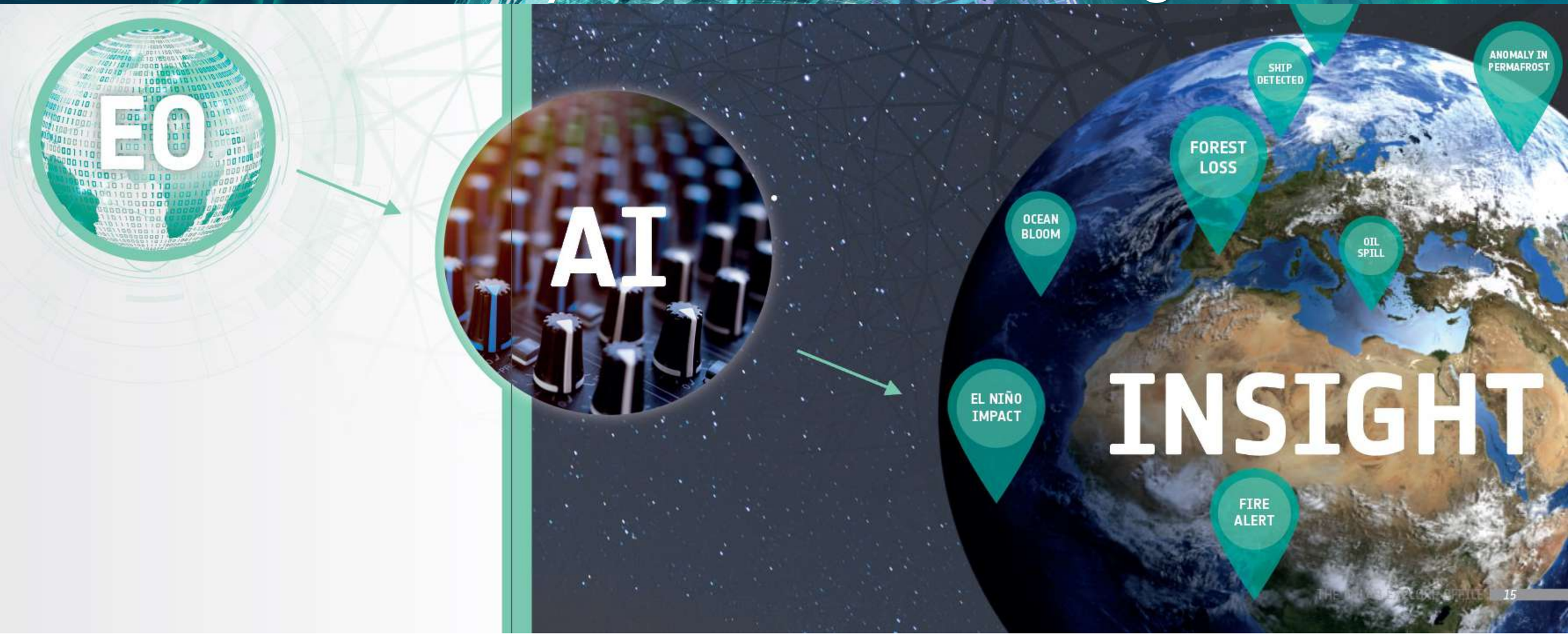


- New Space players
- Broaden customer base
- Large risk capital investments
- From data services to actionable insight and information

- Huge data availability and easiest access
- Constellations with richer sensors
- Copernicus free and open data policy
- IoT in space is coming

- Centralised vs distributed and connected thinking
- Openness toward risky innovation
- Policy makers more open to commercial space vs institutional space solutions

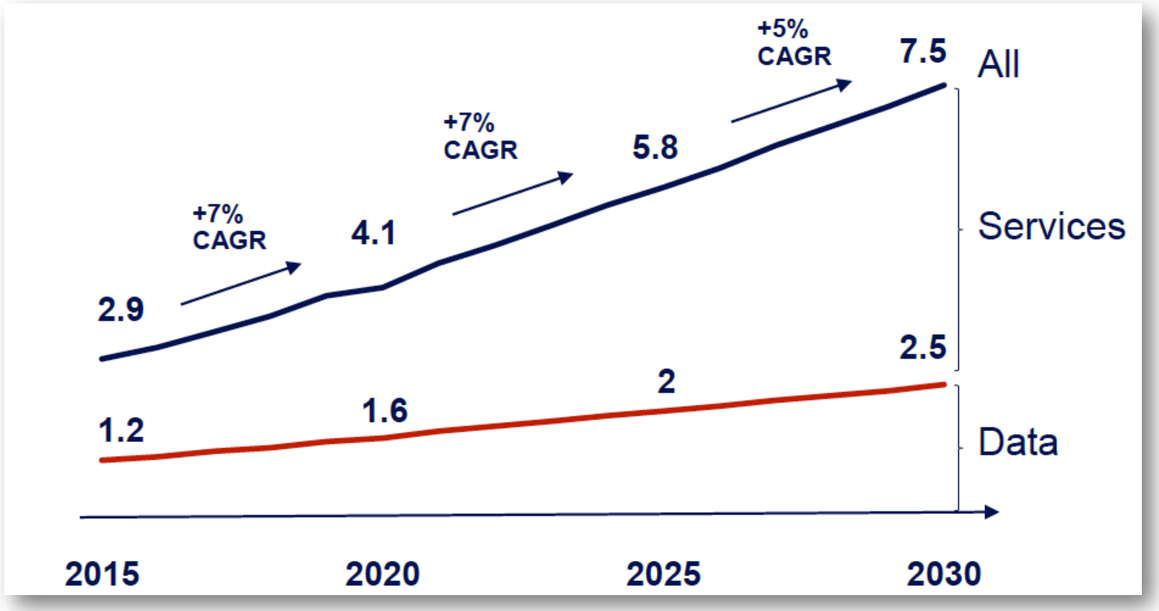
The ESA Φ-lab – Why ? From EO data to Insights



from Earth Observation to Earth Cognition

The ESA Φ-lab – Why?

EO Growth data and VAS



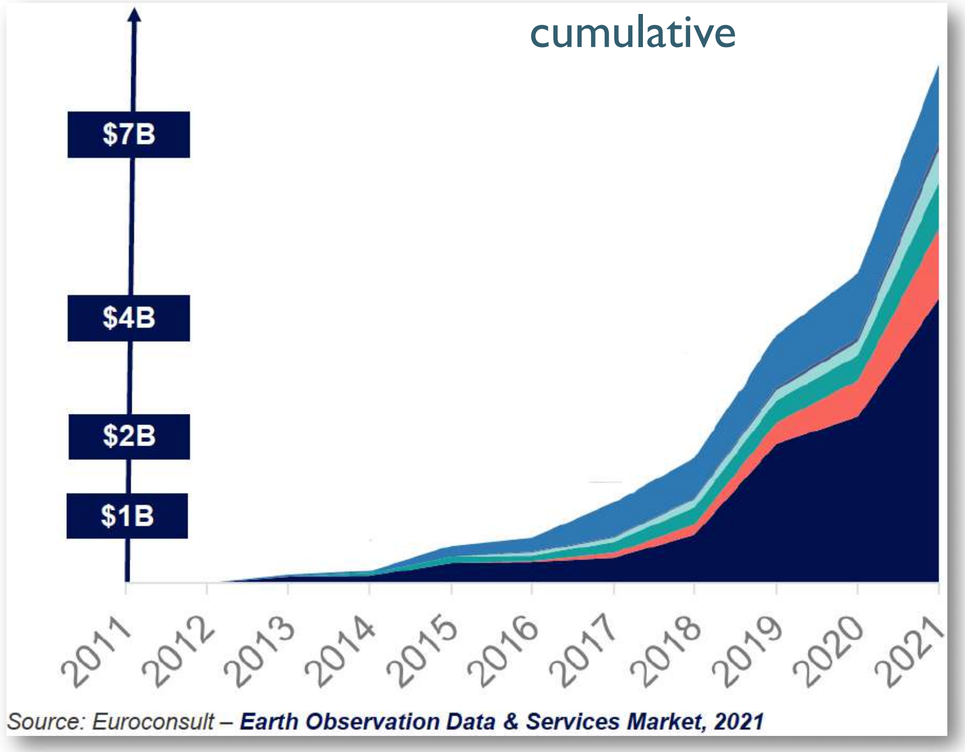
European EO service market

€1.71b revenues (EARSC Industry Survey 2021)

>10%	+24%	+17%
Sustained growth	Number of companies	Number of employees

Source : European Commission, Euroconsult and EARSC

EO private investments



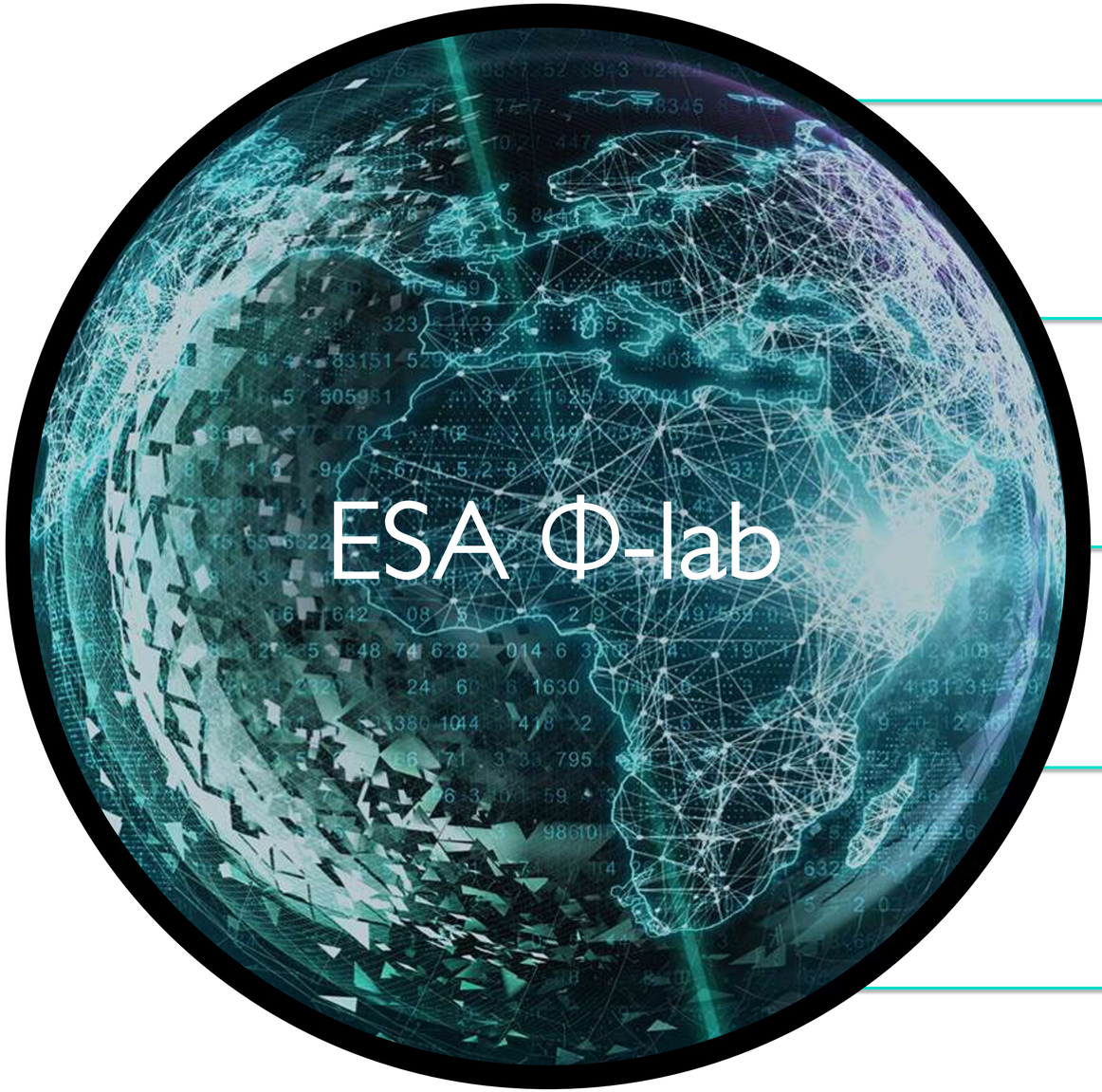
Source: Euroconsult – ***Earth Observation Data & Services Market, 2021***

- Take advantage of the EO perfect storm
- Boost European competitiveness
- Develop and mature the EO market

The ESA Φ-lab location and people

- Based in ESRIN, Frascati – Italy
- Established end 2017
- About 35 members
- 19 partnerships

The ESA Φ-lab tools



Research Lab
Our collaborative and open research environment

Φ-lab Challenges
To stimulate transformational innovation

Φ-lab Community
Our network of companies, researchers, professors and key institutions

Invest Action and InCubed
To facilitate access to innovation investments

Flagships programme
Key programmes as targets of our transformational innovations

Working with us it is easy

- Visiting Professor
- Visiting Researchers (Industrial and Scientific)
- ESA Research Fellowships
- ESA Co-funded PhD
- ESA Young Graduate Traineeships (YGT), Internships, National trainee

Innovation Technologies axis and Applications

AXIS I

Artificial Intelligence and Machine Learning

AI4EO
Detection & Classification, Physic-aware AI, Data Fusion, Prediction, Super-resolution, Quality Control, Calibration, Inversion, Virtual reality

AXIS II

Quantum, Neuromorphic, Edge Computing

To solve demanding Earth observation problems by using new computing paradigms and AI

AXIS III

Internet of Things, Blockchain, Cognitive Space

Flight HW

Flight SW applications

Downstream applications

End to end systems

Business models

Any other innovation in EO is supported for commercialisation

Some of Φ-lab successes*

4

Contribution to AI powered satellites:

- Φ-sat-1 (launched on 02/09/20)
- Φ-sat-2 (under development)
- OPS-SAT
- ESA operational mission

16

External collaborations with companies, agencies, research centres and private investors

€106M

InCubed fund size

56

€73M funded activities @61% co-funding rate

59

Publications on peer reviewed journals and conferences

10

Visiting Professors

17

Visiting researchers

AI4EO
QC4EO

Contributing to European R&D agenda

*The ESA Φ-lab successes: as of August 2022

(some) Collaborations and parternships

esa

Massachusetts Institute of Technology

IARAI

Università degli Studi del Sannio

TUM

Technische Universität Berlin

POLITECNICO MILANO 1863

EPFL

CERN

DLR

ASI Agenzia Spaziale Italiana

lrz

SatCen European Union Satellite Centre

ECMWF

Die Österreichische Hagelversicherung

Vniversitat de València

unicef

WFP

Università di Roma Tor Vergata

Jožef Stefan Institute

ETH

Istituto Nazionale di Geofisica e Vulcanologia

KP LABS

IIASA

PI SCHOOL
MACHINE INTELLIGENCE
MEETS HUMAN CREATIVITY

ellis
European Laboratory for Learning and Intelligent Systems

PRIMO SPACE

ICEYE

cosine

SATLANTIS

AIRBUS
DEFENCE & SPACE

OHB

OPEN COSMOS

CGI

LEONARDO

TELESPAZIO
a LEONARDO and THALES company

e-geos
AN ASI/TELESPAZIO COMPANY

Maker Faire

SLUSH

CSEOL
CITIZEN SCIENCE EARTH OBSERVATION LAB

FDL

CLAIRE

The ESA Φ-lab Offices

Φ-lab Explore Office

Explore the innovation universe
connecting EO sensor revolution
with the digital revolution

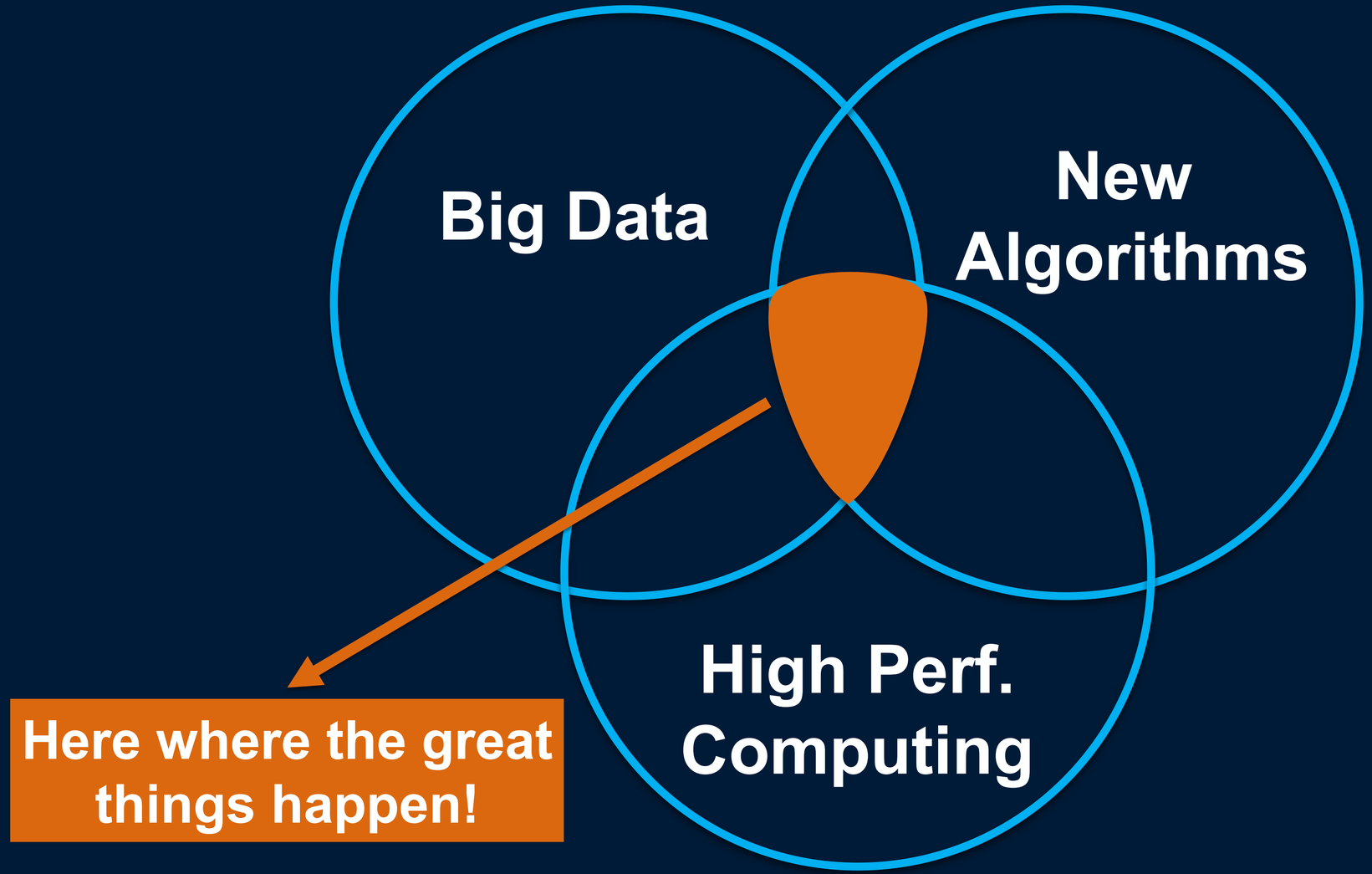
Team of Researchers
and an innovation seed funding (FutureEO)

Φ-lab Invest Office

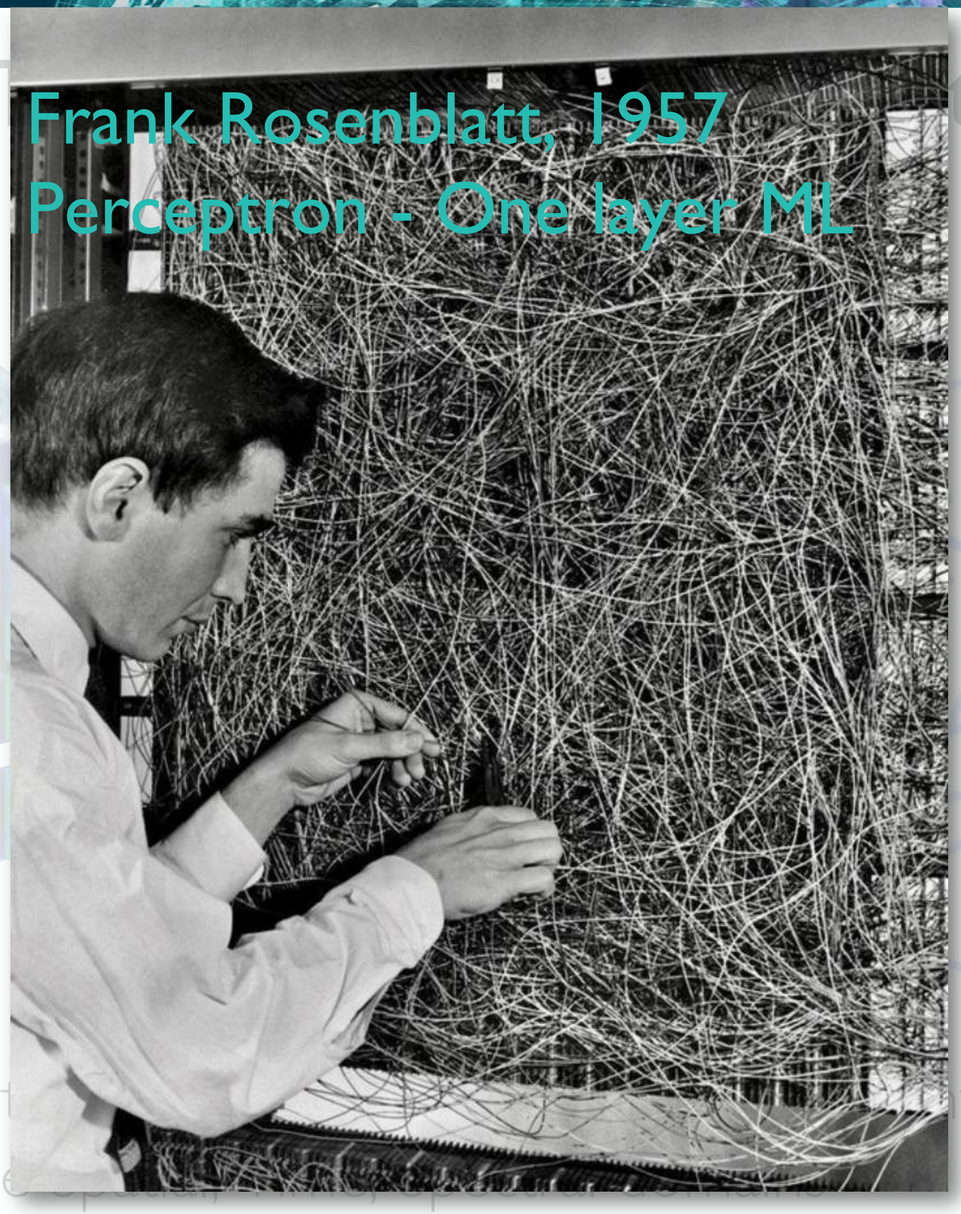
Stimulate competitiveness fostering entrepreneurial
initiatives growth with investment actions from ESA MSs
and private investors

Team of Business Innovators
and commercial co-funding programme (InCubed)

The ICT, AI and ML Revolution in EO



The Deep Learning Big Bang

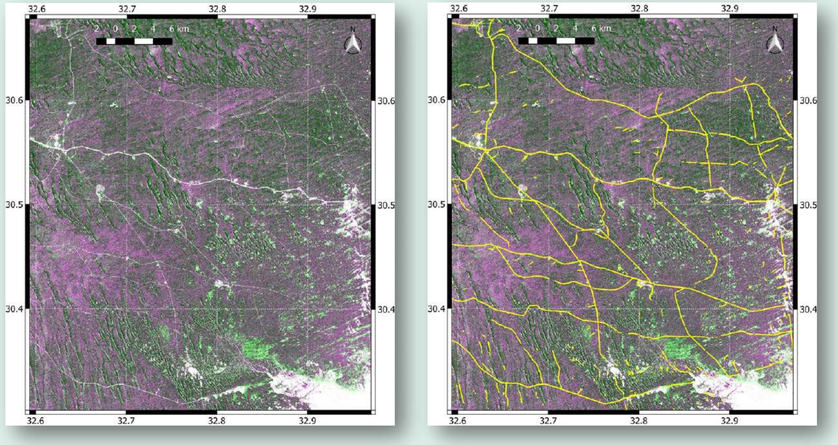


Frank Rosenblatt, 1957
Perceptron - One layer ML

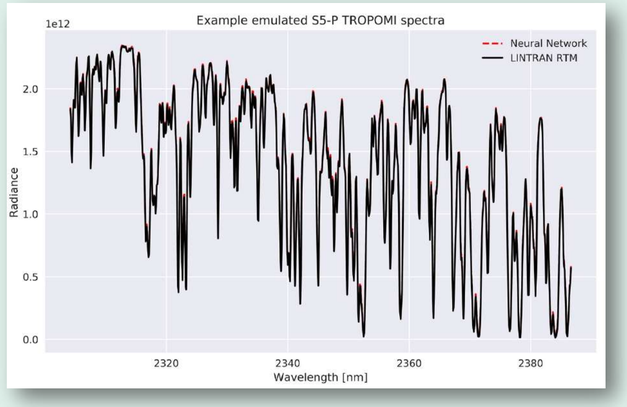
Feature Detection & Classification

- Crops
- Oil Palm
- Ships
- …

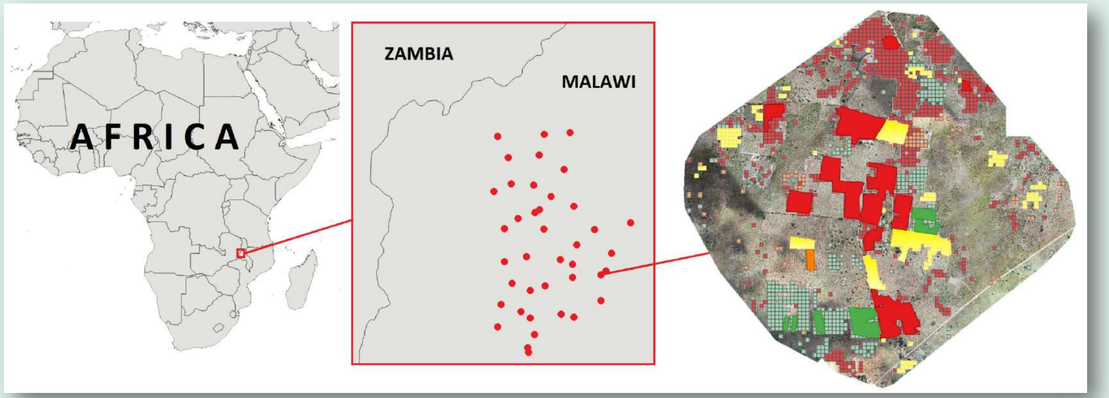
EXPLORE Use Cases – Some examples



Infrastructure monitoring in desert regions



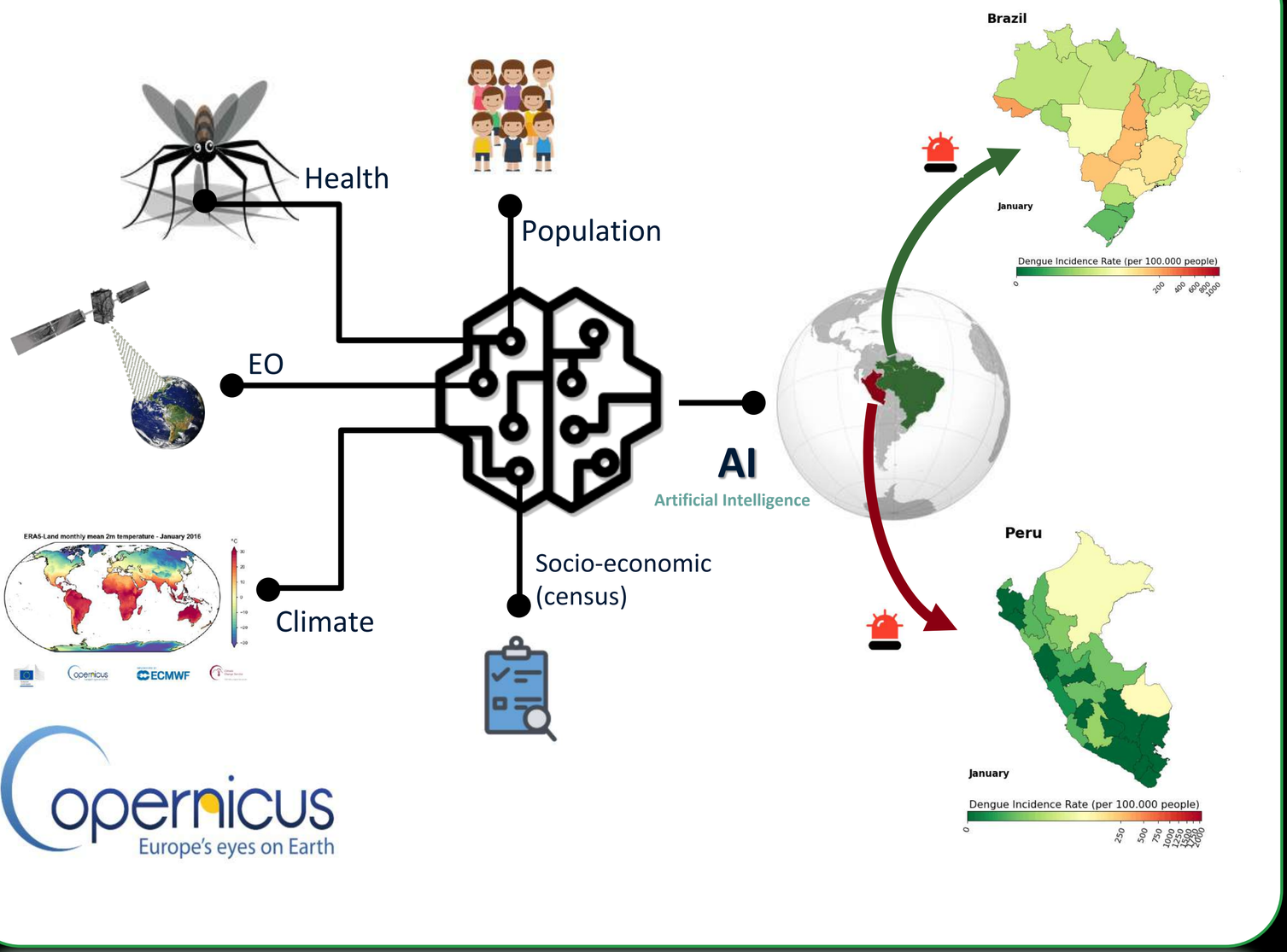
Physics-aware machine learning emulation of RTMs
Copernicus Sentinel-5p methane retrieval



Crop types mapping using drones,
Copernicus Sentinel-2 and daily life images

Use of AI for SAR image for on-board
object detection and classification

Quantifying health-risk with EO data and AI (application to Dengue)



UNESCO | IRCAI Global AWARD

Top 100 AI solution for SDGs

to Φ-lab team for their work on forecasting dengue outbreaks with UNICEF

GLOBAL TOP 100
GLOBAL TOP 100
PROMISING PROJECT
PROMISING PROJECT

"This project is a perfect example of collaboration between a humanitarian organisation and a research entity to support the UN SDGs."

Dohyung Kim
Lead Data Scientist at the UNICEF Office of Global Innovation.

QC4EO

AI-enhanced Quantum Computing for EO

CERN

esa

DLR

ECMWF

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

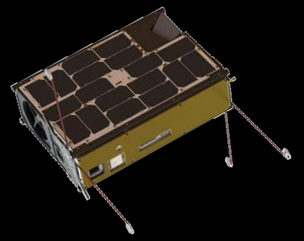
NICOLAUS COPERNICUS ASTRONOMICAL CENTER OF THE POLISH ACADEMY OF SCIENCES

UNIVERSITY OF WARSAW

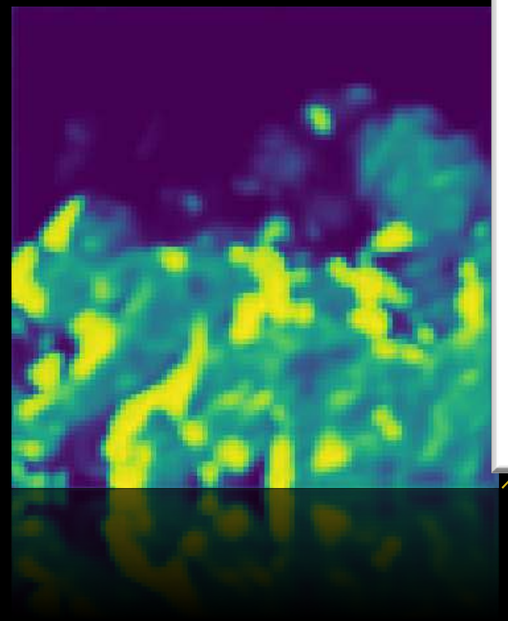
JAGIELLONIAN UNIVERSITY IN KRAKÓW

ellis European Laboratory for Learning and Intelligent Systems

Φ-sat-1 is the first AI-powered European EO mission



AI-computed Cloud mask



Cloud mask superimposed on

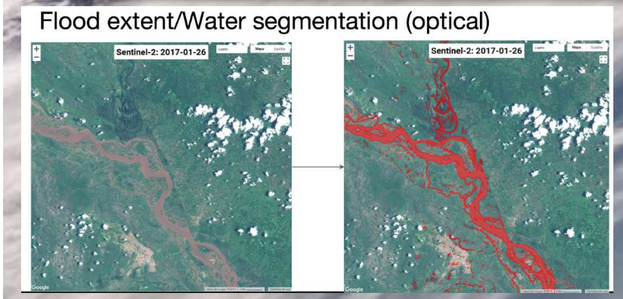
AI on Φ-sat-2
and
Copernicus expansion missions
and
more..

The Myriad 2 chip

Image: Maximilien Brice/CERN

the Φ-sat-1 neural networks are perfectly working with the expected performance

Europe has precursors: Cognitive Cloud Computing Node in Space running suite of Machine Learning Apps



Nebula payload
On-orbit Cloud
Computing Node
(UNIBAP SpaceCloud)

Re-programmable
AI Brain

Testing “Worldfloods” which have the ability to identify flooding and send down a flood map to emergency responders seconds after image acquisition. The Machine Learning SpaceCloud App is developed by the Frontier Development Lab (FDL), a partnership led by Trillium Technologies with the University of Oxford and ESA

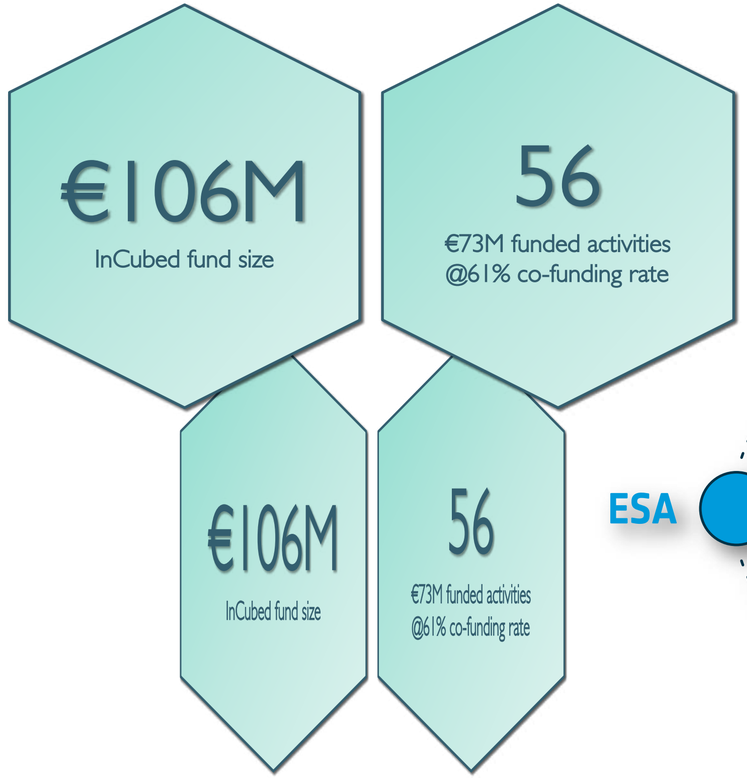
D-Orbit Wild Ride Mission, launched 30 June 2021
ION Platform with 6 cubesats, 20+Machine Learning Apps on SpaceCloud

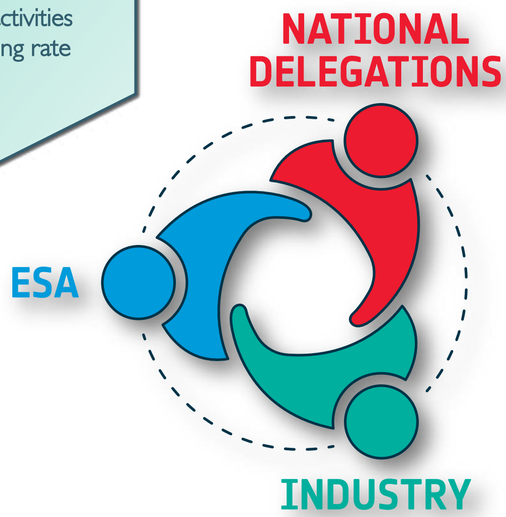
D-ORBIT UNIBAP FDL

SPACECLOUD UNIBAP D-ORBIT WILD RIDE - ION SCV 003

Φ-lab run Investing in Industrial Innovation (InCubed)

What is it	industry-led commercial programme
Focus	develop EO innovative & commercially successful products and services
Scope	anything from building satellites to data platforms, flight HW and SW and innovative business models
When	Always, it is an open call
Who	Industry, ESA and National Delegations



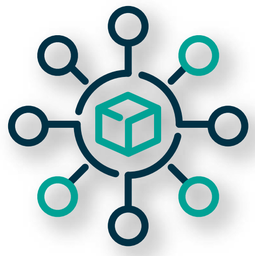


Personalised guidance
technical and commercial support

Zero equity and
IPR full ownership

ESA stamp of
credibility

Access to ESA
EO facilities and Φ-lab



Membership
of the Φ-lab community

InCubed Activities – Some examples

Innovative solutions for VHR EO satellites, AOCS and the Instrument for high-quality VHR satellite imagery and geo-analytics

deimos elecnor group | SURREY | TELEDYNE e2V Everywhereyoulook™

MultiSpectral Companion Mission

To provide a daily global coverage, high quality multispectral data product, with interoperability with Sentinel-2 data products.

aerospacelab

ai4eo SOLUTION FACTORY

Combine EO data and AI tools to identify new business cases addressed with customized solutions, created in a knowledge base and modules repository factory

DFKI | VISION IMPULSE

AIX SMART IN-ORBIT DATA PROCESSING

AI-express (AIX) is a hybrid edge ecosystem based on state-of-the-art technologies (AI with dedicated processing units and Blockchain) targeting reactivity, responsiveness, and low-latency

planetek italia | AIKO INFINITE WAYS TO AUTONOMY | D-ORBIT

InCubed Activities – Some examples

EO PLUG-IN HUB

Improve potato production yield. A paradigm change for Earth observation integration in the agro-food industry

GeoVille HLB research and consultancy in agriculture HERMESS eodc

Signaleyes

A clear view on change

SignalEyes analyses spatial changes in objects including buildings, trees, water courses and roads.

NEO

HyperScout-2 for the FSSCAT mission. Miniaturized hyperspectral and thermal imaging coupled with Artificial Intelligence for breakthrough operational space missions

cosine

mantis

MANTIS is a demonstration mission to develop, build, launch and operate an innovative nanosatellite that will fly a high resolution camera

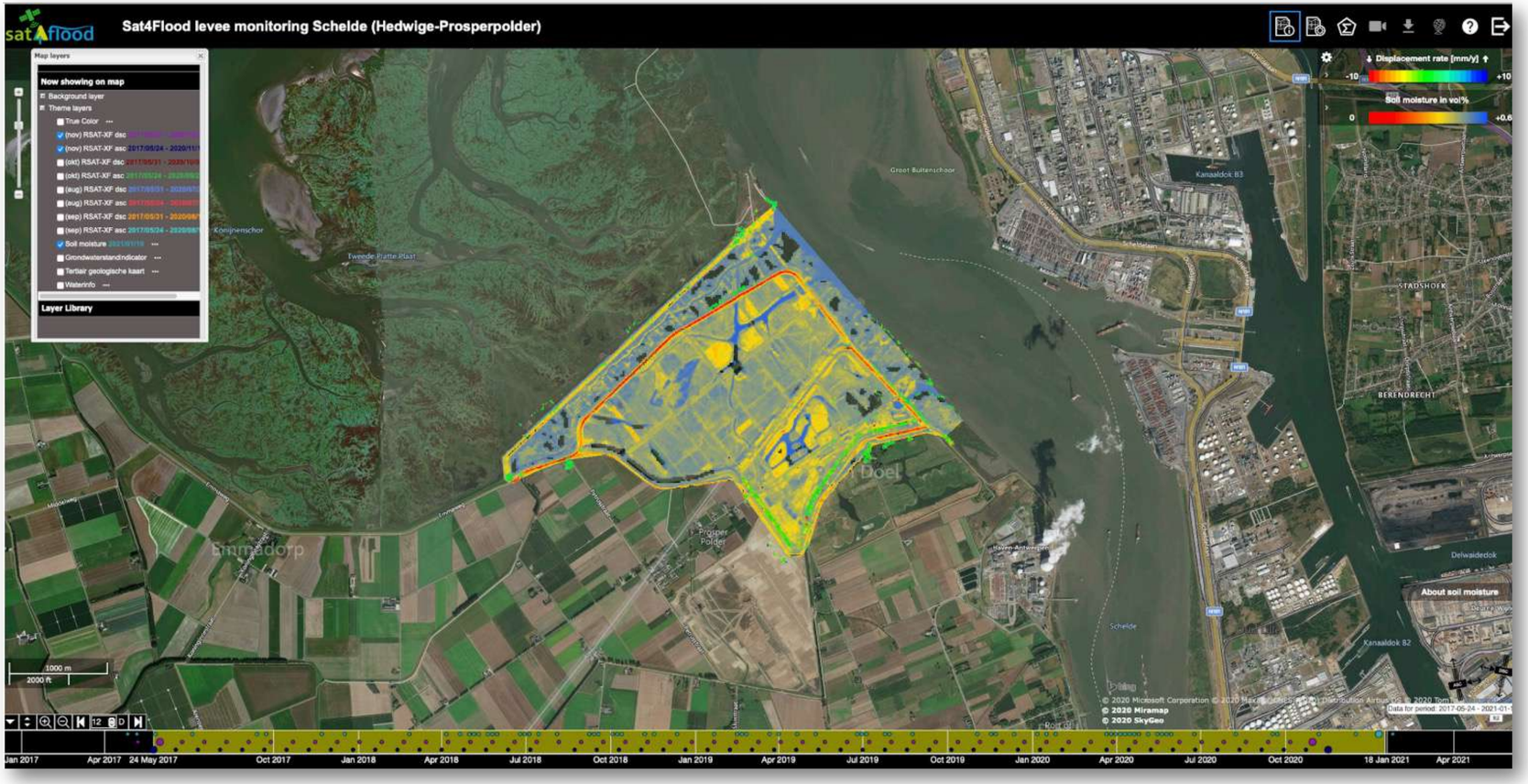
OPEN COSMOS Terrabotics Space to Earth Analytics SATLANTIS

InCubed Activities – Sat4Flood

miramap SKY GEO 52impact

- Sat4Flood by Miramap (NL) globally **visualizes the risks of levee failure** based on the most recent Earth observation satellite data.

- This development combines the innovative technologies of satellite **high-resolution soil moisture** data with Interferometric SAR deformation data and other Earth observation data sources.



InCubed Activities : Deep Property

- Deep Property by Ticinum Aerospace (IT) enables **automated extraction of building features** thanks to proprietary AI-based techniques applied to geospatial datasets.

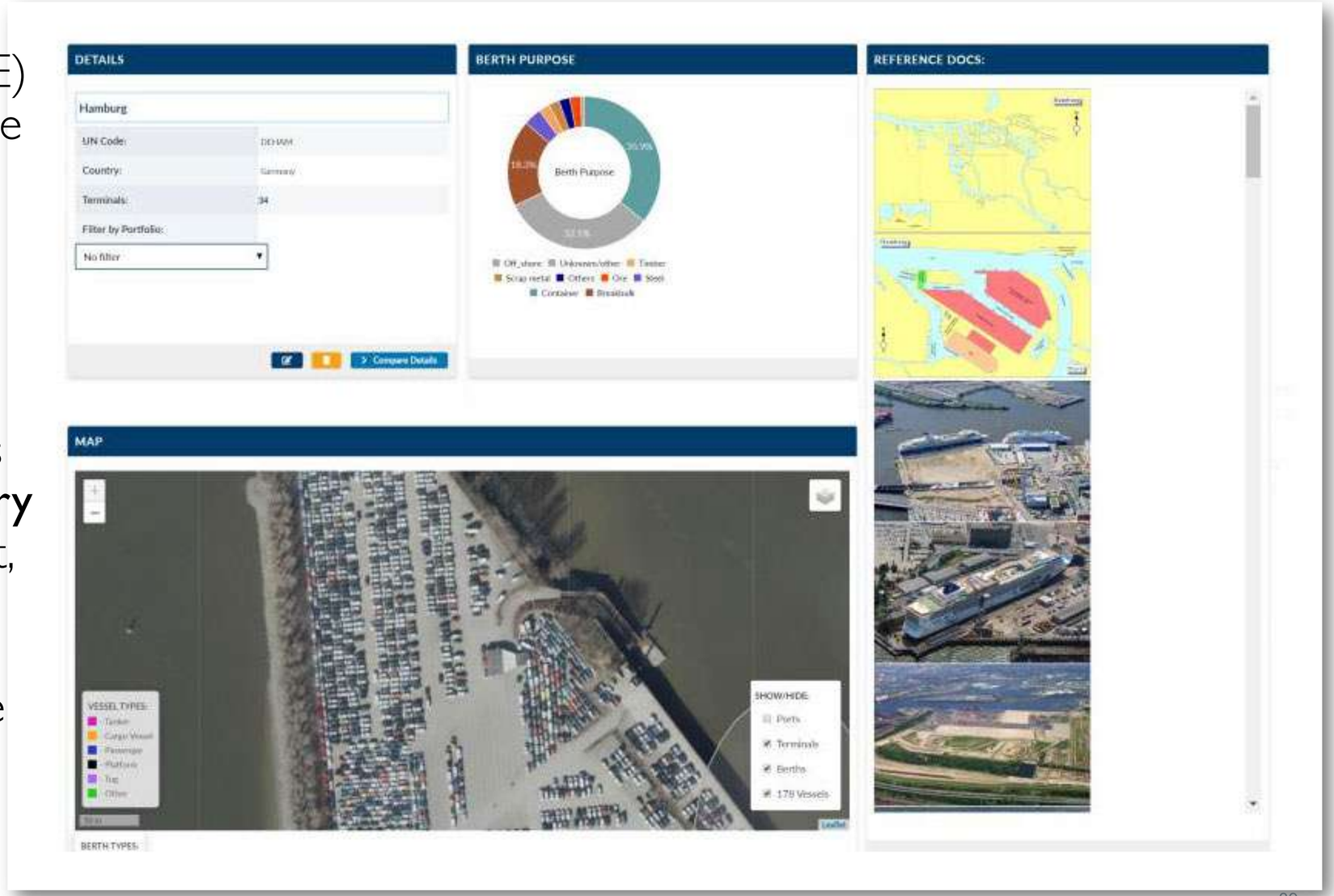
- The core market is the **re/insurance sector**, where these fine-granularity data improve the businesses' efficiency in multiple areas including **underwriting risk modelling and pricing.**

InCubed Activities : Cargo Port Analysis Using EO and esa

skytek

- Cargo Port Analysis by Skytek (IE) for the insurance and reinsurance industry.

- The existing product (REACT) was extended to incorporate more advanced modelling and processing of new data sources including space assets, **EO imagery and Navigation data.** As a result, this platform provides a **more detailed and enhanced overall picture of risk exposure** to the insurance industry.



Thank you for your attention

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