living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

MONICAP - A HAPS-based permanent and sustainable system for precision agriculture

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26 MAY 2022

About Us and the Project

Hypatia Research Consortium

Hypatia is a private research consortium, born in 2008, whose main objectives are the promotion, development and valorisation of the territory's scientific, technological and human resources.

Departments

Life Sciences
Advanced Manufacturing
Electronics and New Materials
Earth Observation and Telecomm

HYPATIA

MONICAP - MONItoraggio di **C**olture **A**gricole **P**ermanente

E. Amaldi Foundation

E. Amaldi Foundation is an Italian institution for applied research, technology transfer, promotion and support of the national scientific heritage. Established in 2017 by the Italian Space Agency (ASI) and the Hypatia Research Consortium, it aims to offer a new way of interpreting applied science.

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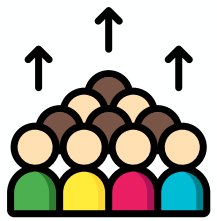
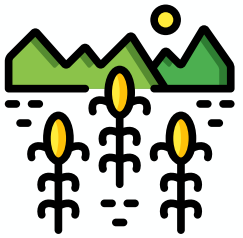
Context

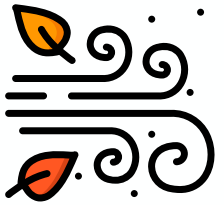
Threats



Population increase

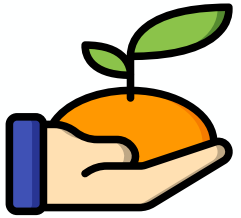


Scarce increase in cultivable areas



Climate change

Needs



Less resources waste

Less pollution

Higher profitability

New challenges

- **Increased production** for the increased needs of the growing population with the **least possible environmental impact**;
- **Reducing costs** to make products accessible to an increasingly poorer segment of the population;
- Maintaining **high production levels** with **greater efficiency** and therefore, a **lower environmental impact** due to both lower greenhouse gas emissions and nutrient containment.

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MONICAP Precision Agriculture

Agronomic techniques and resolution

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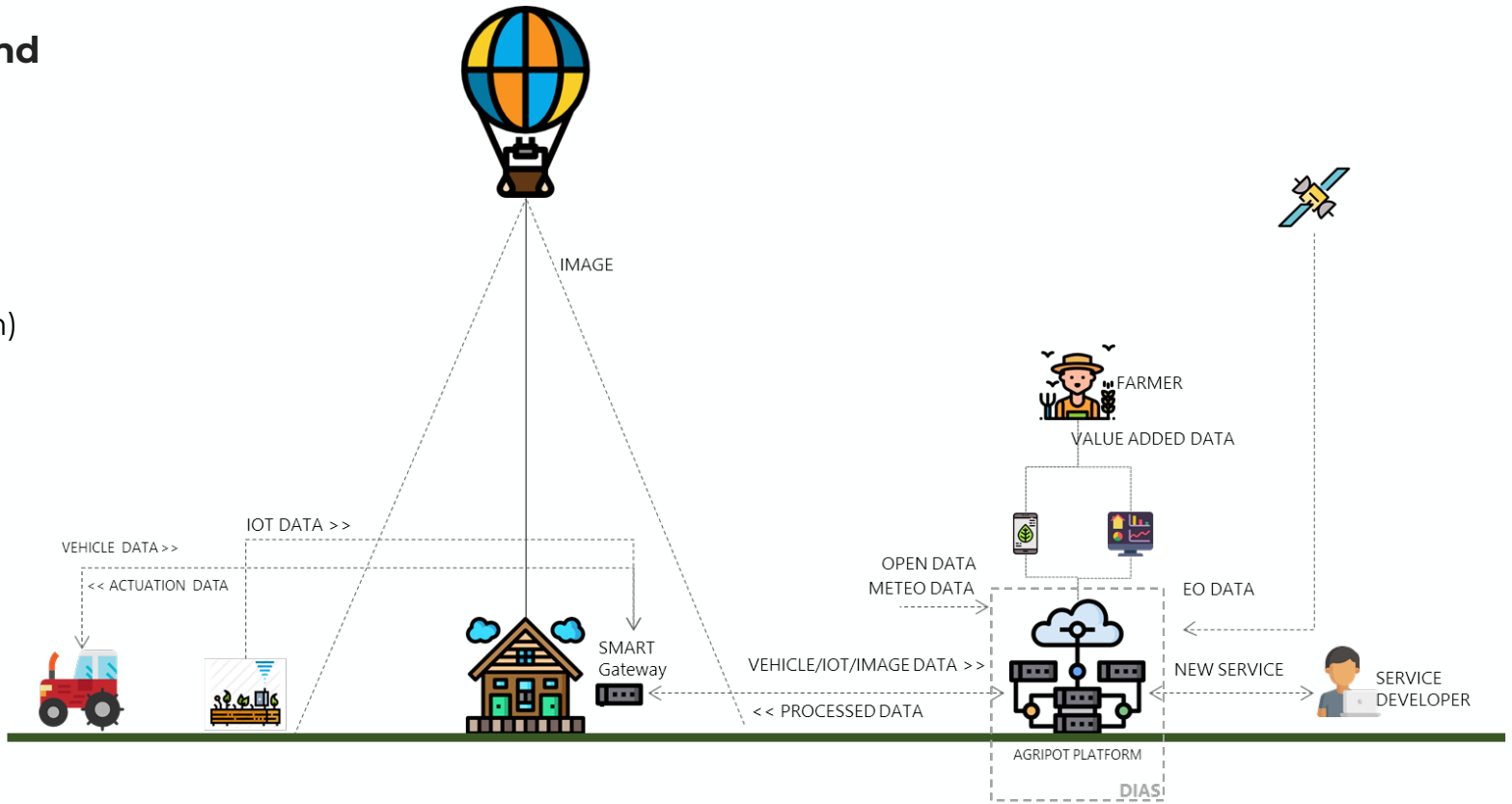
MONICAP ..in a nutshell

MONICAP is a plug&play solution for the systematic monitoring of agricultural areas and the provision of data/services for precision agriculture based on the use of an energy-independent captive aerostatic system.

MONICAP is the HAPS technology and sensor validator.

- Easy to use and manage
- Low installation and maintenance costs
- Energy independence
- Monitoring persistence (tethered aerostatic platform with photovoltaic power generation)
- Ability to use high performance payloads
- Open system, integrable with new data and services
- High frequency of acquisition, real time data elaboration, and high resolution



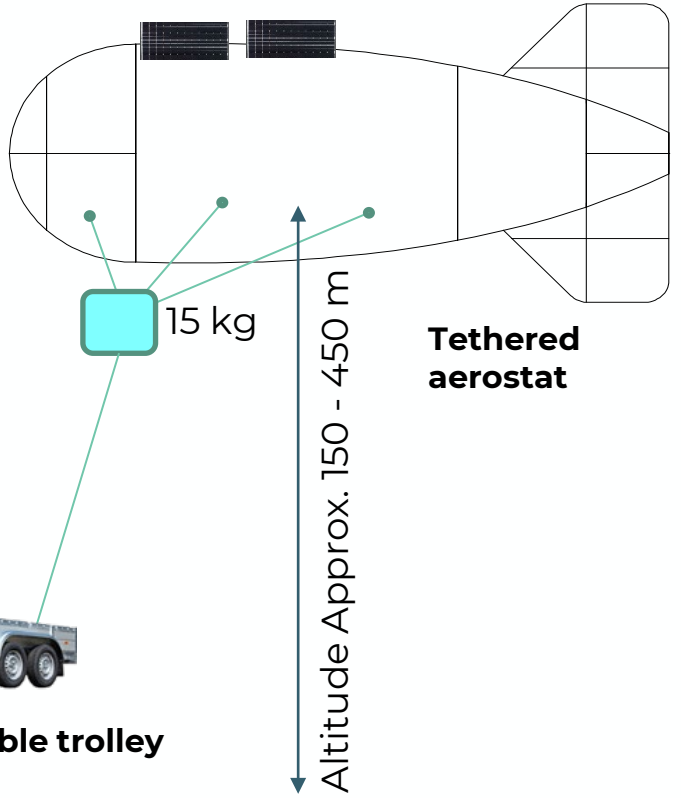
MONICAP
the platform

- Autopilot and GPS RTK
- Multispectral/Iperspectral LWIR and Visible
- Wirless Data Link
- Battery and Flexible Solar Panels

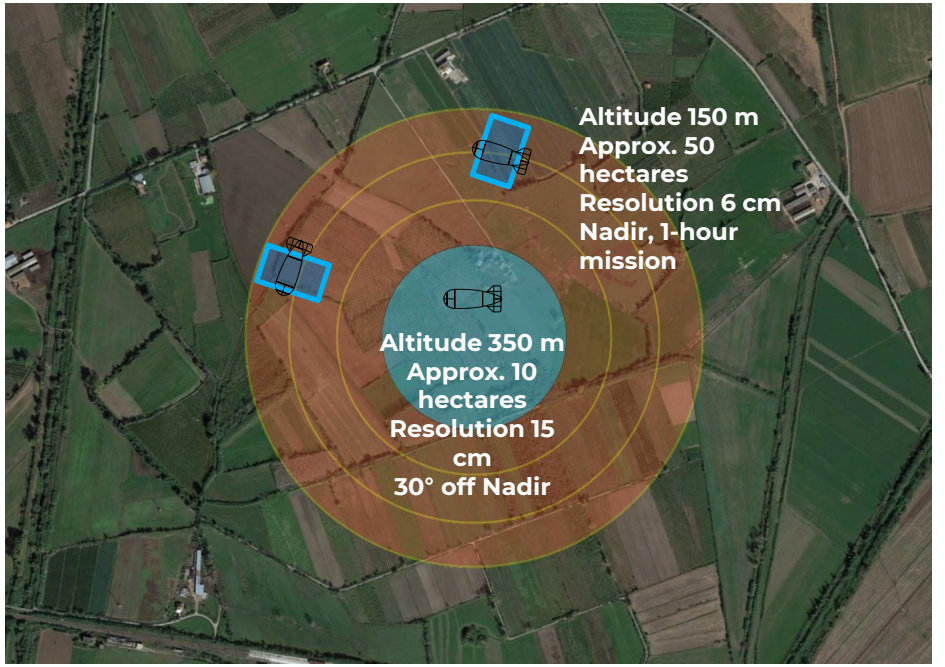
Meteo Station

Transportable trolley

Ground Control Station



Tethered aerostat



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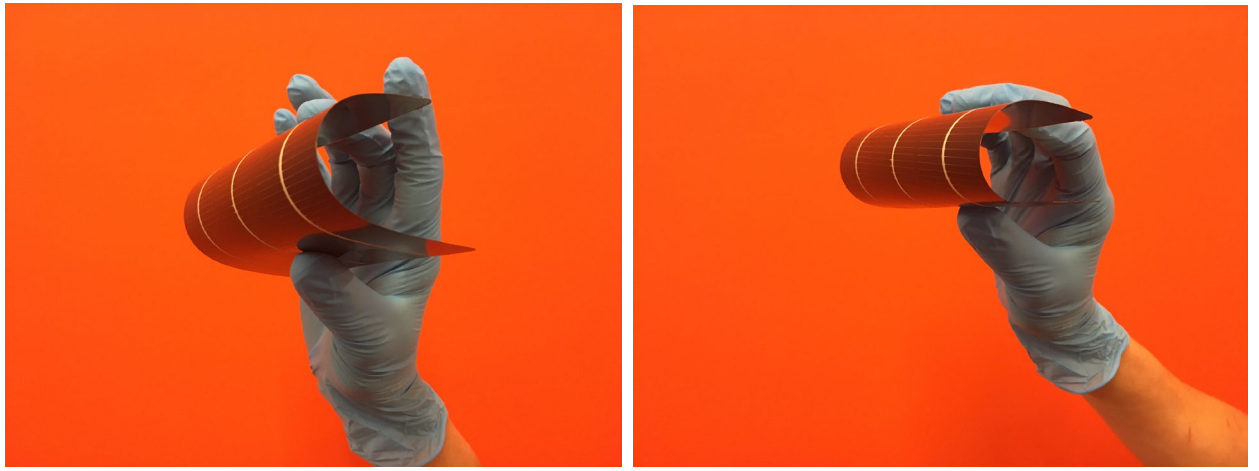
MONICAP
energy independence

The need to create an autonomous electrical energy generation and storage system on board the aircraft is easily justified by the reduction in the weight of the cable by more than 50Kg which would drop to about 1.5Kg with the same breaking load of 250Kg.

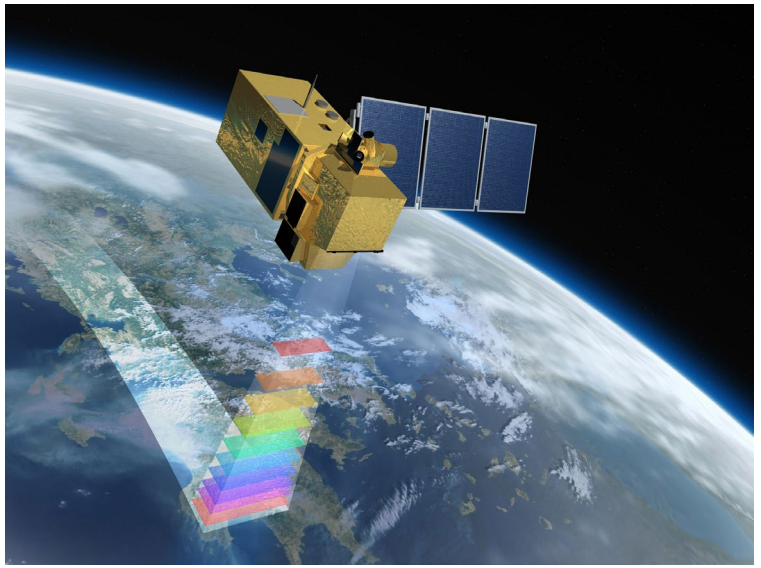
The weight of the generator and accumulator will be optimised using flexible, ultra-light cells with >500W/kg efficiency and batteries with >300Wh/Kg capacity.



Technology	Cost*(€/W)	Efficiency	Flexibility	Power/Weight (Wp/Kg)	Notes
CIGS Hypatia on titanium	5-12	12-15%	excellent	500-1000	Mature technology requires no radiation-resistant screen

*Costs in the production phase

MONICAP vs. drones vs. satellites



Sentinel-2 credit: ESA

vs. drones

- **PERSISTENCE OBSERVATION**: MONICAP uses tethered balloon technology and has a longer stay in the air than drones.
- **LARGER LOAD CAPACITY**: An aerostatic platform has a higher load capacity than other aircrafts with the same consumption.
- **LOWER SERVICE COST**: Compared to standard aircraft and drones, MONICAP has a lower operating cost for the same number of flight hours, both because a pilot is not required and because there is a low energy consumption, which translates into a lower service cost.
- **SAFETY**: MONICAP, using a tethered platform, has an intrinsic safety feature with a recovery winch that prevents loss or falling in unwanted places.

vs. satellites

- **FREQUENCY OF ACQUISITION**: satellite systems do not allow the persistent observation of an area of interest as can be achieved with MONICAP.
- **SPATIAL RESOLUTION**: MONICAP will provide high spatial (sub-metric) resolution data for both multispectral and thermal sensor data.
- **DELIVERY TIMES**: MONICAP, using different technologies for both image acquisition and data collection and dissemination, will be able to deliver the data with minimum latencies.
- **POSSIBILITY OF REAL TIME PROCESSING**: High-performance data processing hardware devices and innovative algorithms are able to provide the user with short time information on crop status and predictions.

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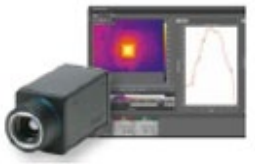
sensors and algorithms

VIS+NIR

Hyperspectral

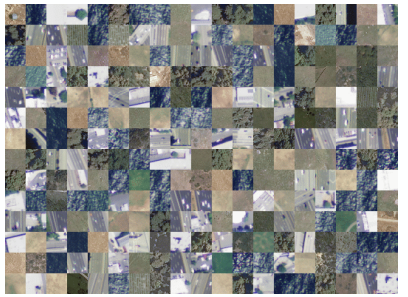
LWIR



ML Algorithms

- Deep Neural Network (DNN)
- Support Vector Machine (SVM)
- Random Forest (RF)
- Convolutional Neural Network (CNN)
- Long short-term memory (LSTM)

Dataset



SAT-6 dataset, in which the images were sampled from the National Agriculture Imagery Program (NAIP) dataset.

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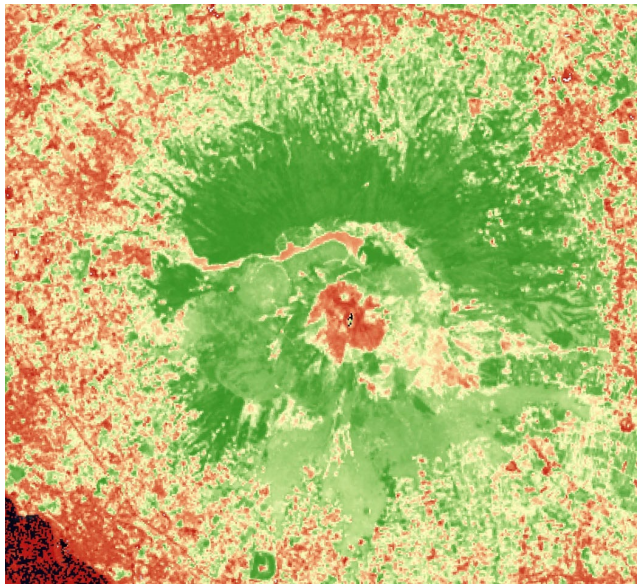
MONICAP

vegetation indices



NDVI: $\frac{(NIR-R)}{(NIR+R)}$

Photosynthetic activity, through interpretation of the fraction of photosynthetically active radiation absorbed by the plant

GNDVI: $\frac{(NIR-G)}{(NIR+G)}$

Photosynthetic activity, it is more sensitive to chlorophyll concentration than NDVI and is more useful **at a late stage in the culture**.

NDRE: $\frac{(NIR-RE)}{(NIR-RE)}$

Measures photosynthetic activity, but is often used to **plan the harvest**.

ENDVI: $\frac{((\mathrm{NIR}+\mathrm{G})-(2*B))}{((NIR+G)+(2*B))}$

The index complements the previous ones as the absorption of blue light by vegetation combined with the high reflectance of green and near-infrared light appears to be a **reliable indicator of plant health.**

VARI: $\min\left(1; max\left(\left(-1; \frac{(G-R)}{(G+R-B)}\right)\right)\right)$

Allows you to **estimate the amount of vegetation** in a region of interest.

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MONICAP applications

Yield Estimation: Achieving maximum crop yield at minimum cost with a healthy ecosystem through early detection and management of crop-related problems.

Nitrogen management: Nitrogen plays a significant role in the process of photosynthesis and is important for crop health and development. At the same time it has a significant environmental impact that requires prudent management.

Disease detection: One of the most significant concerns in agriculture is diseases from pests, greenhouse conditions or open-air agriculture. The most common practice in pest and disease control is to use pesticides uniformly over the growing area. This practice, although effective, has a high financial cost and significant environmental impact.

Weed detection: Many producers point to weeds as the most important threat to agricultural production. Accurate weed detection is of great importance for sustainable agriculture, as weeds are difficult to detect and discriminate from crops.

Crop quality: The detection and classification of crop quality can increase the market value of the product and reduce waste.

Species recognition: The main objective is the automatic identification and classification of plant species to reduce costs and classification time.

Soil management: Of paramount importance is the predictive identification of agricultural soil properties, such as the estimation of soil dryness, condition, temperature and moisture

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MONICAP conclusions

- The systematic and widespread use of systems of the MONICAP type could lead to a precision mapping of the territory and to a clear vision of the state of health and of the observed or predicted evolutions of the different crops in action in the territory; **MONICAP is a precursor to HAPS that will allow technology and sensor validation with extreme flexibility and adaptability.**
- The objective of MONICAP is not to compete with the satellite or aerial technologies used today but **to enable the integration of data from HAPS with data from all other sources.**

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THANK YOU FOR THE ATTENTION!