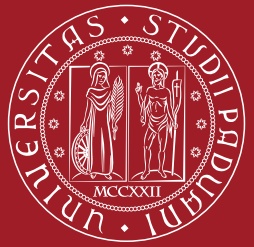


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# Aerospace Technologies for Earth Monitoring and Observation

Federico Toson - 38th Cycle

Supervisor: Prof. Carlo Bettanini

Co-Supervisor: Prof. Giacomo Colombatti

3° year admission - 16/09/2024

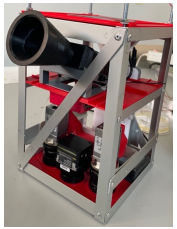
# International Framework and Objectives



**Motivation:** Environmental safeguard

**State of Art**: Ground and satellite technologies for Earth monitoring

# Design and Development



Use of previous technologies for remote sensing studied by the research team (AREO, MINLU, OZONE)

Improvement and versatility not only in analysis and monitoring but also in context (area, heights, hosting vehicles)

Multiple subsystems

Rapid prototyping

Autonomous payload

Additive printing

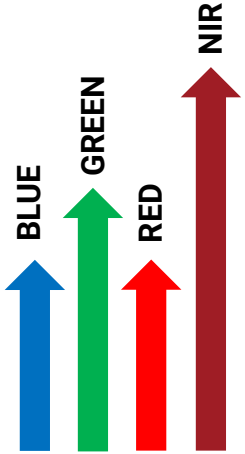
SAT data integration and validation

## Three possible solutions:

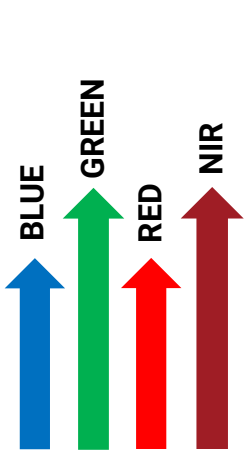
- Drones:
  - High ground resolution
  - Limited time window
  - Easy access
  - Defined ground track
- Stratospheric Balloons
  - Large area of analysis
  - Extended time window on different target area
  - Variable ground track (atmospheric wind dependant)
- Tethered Balloons
  - Extended time window on specific target area
  - High ground resolution

# Vegetative indexes computation

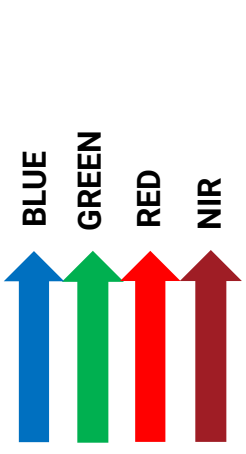


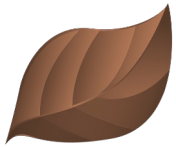


**Healthy Leaf**



**Stressed Leaf**



**Dead Leaf**

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

$$GNDVI = \frac{NIR - Green}{NIR + Green}$$

$$NDRE = \frac{NIR - RE}{NIR + RE}$$

$$ENDVI = \frac{(NIR + Green) - 2Blue}{(NIR + Green) + 2Blue}$$

# Satellite Example

**Constellation of 130+ CubeSat in SSO**

(revisit time of 24h on the field, at 9 am LT)

planet.

**8 satellites' operative bands (ground res. 3,2 m):**

- Coastal Blue (431 - 452 nm)
- Blue (465 – 515 nm)
- Green I (513 - 549 nm)
- Green (547 – 583 nm)
- Yellow (600 - 620 nm)
- Red (650 – 680 nm)
- Red-Edge (RE) (697 – 713 nm)
- Near-Infrared (NIR) (845 – 885 nm)

# Imaging unit and sensors

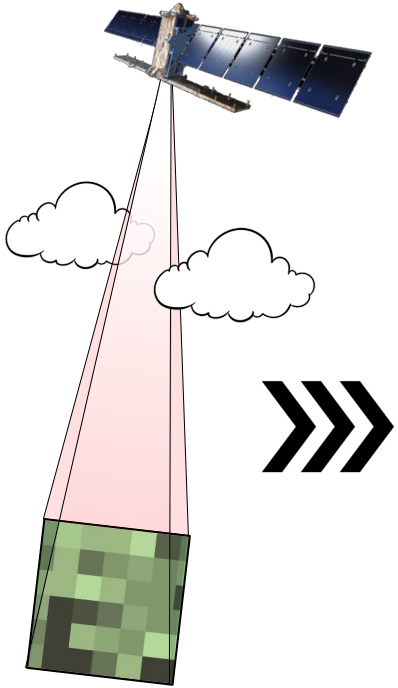
- Basler ace 2 (IMX546 8MP CMOS by Sony)
  - monochromatic camera
  - colour camera
- FLIR Vue Pro R
- Apeman "Space cam"
- Two main optical solutions

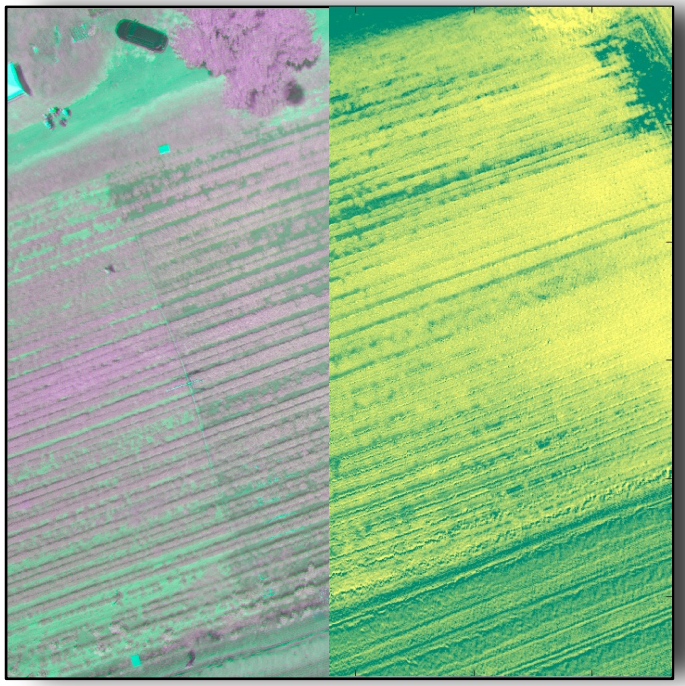
| | Focal Length | Angle of View | FOV @ 50 m height |
|---|---|---|---|
| Kowa LM35HC | 35 mm | 13° | 12 x12 m |
| Tuss LYM0814 | 8 mm | 70° | 100 x 100 m |

- SQM-L (Sky quality meter)
- Air composition sensors
- GPS system

# Previous developments

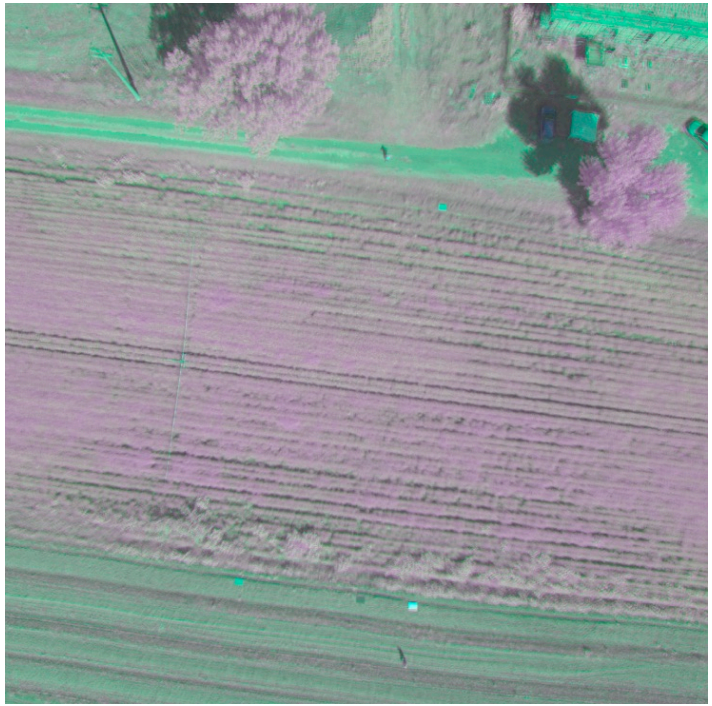


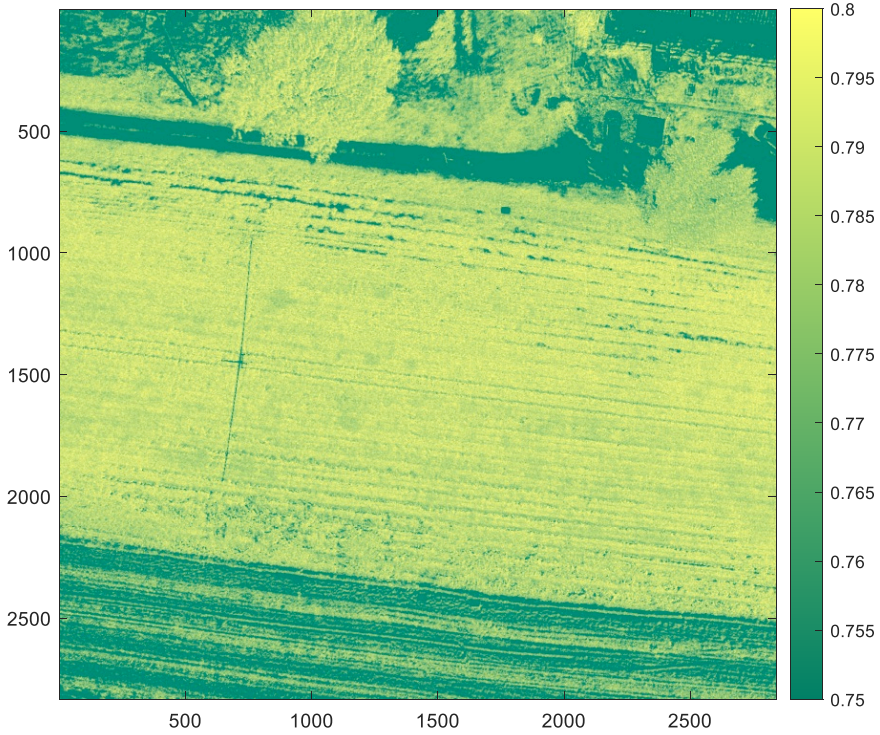




# Data Elaboration (Cortona)







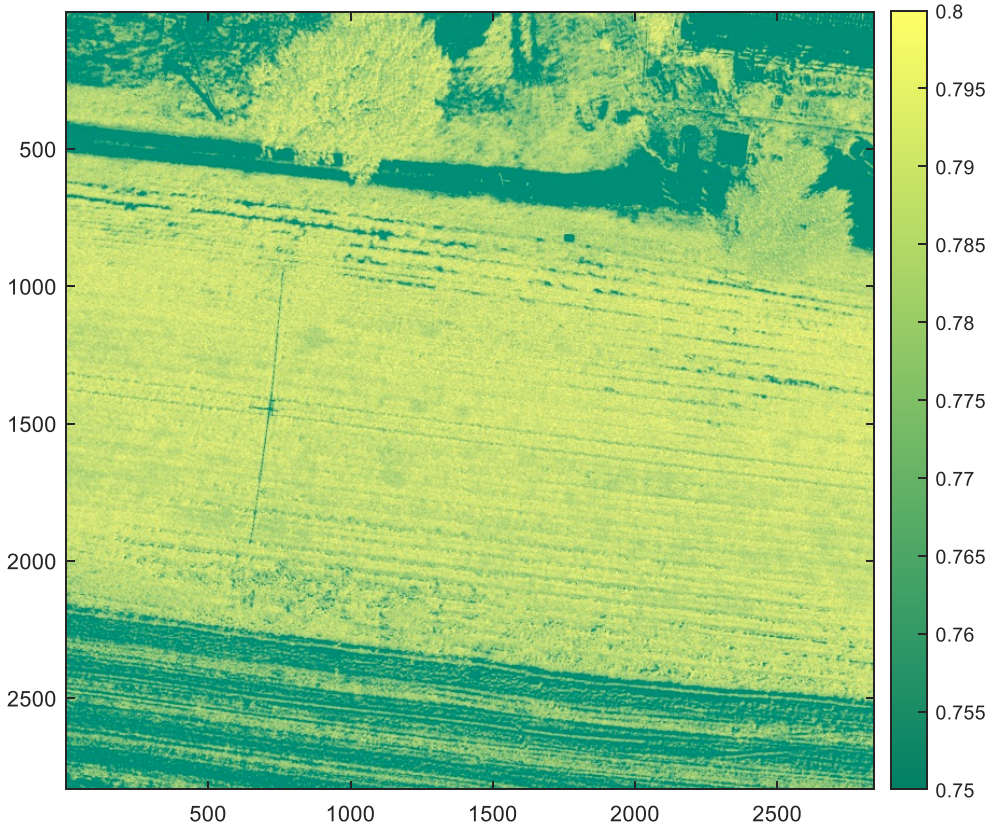

RAW image in RGB TB filter (475, 550, 850 nm)

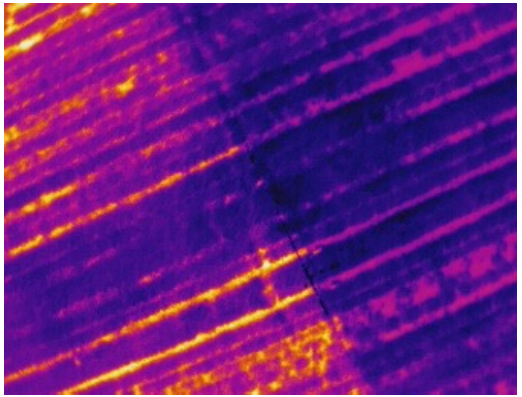
Slides credits to Carlo Bettanini

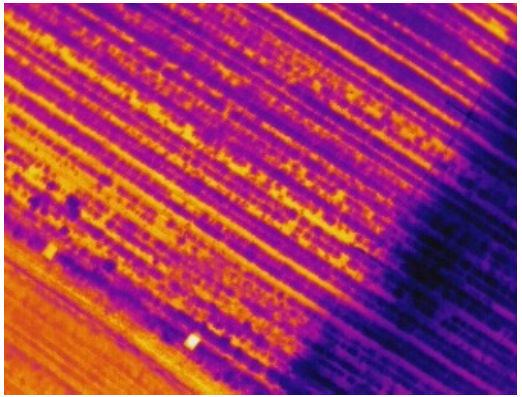
GNDVI computation

# Thermal-camera data integration



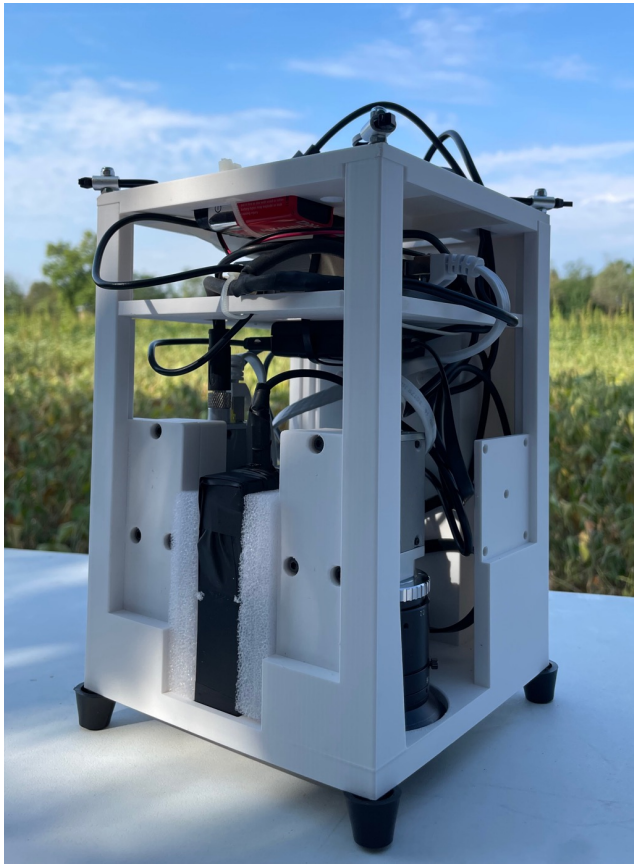




# New developments





- New 3D structure
- Modular approach
- New field test campaigns
  - Water stress
  - Wine yard diseases
  - Light Pollution
- Stratospheric flights
  - Attitude and Dynamics reconstruction

# On-going and future collaborations



- **DAFNAE & TESAF**: Crops monitoring study *(currently in progress)*
- **University of Pisa:** Stratospheric balloon launches *(October 2024)*
- **University of Chile**: Light Pollution research *(November 2024)*
- **Officina Stellare**: Sat observation data *(2025 TBD)*
- ***ESA Earth Observation office*** *(2025 TBD)*

TESAF Dipartimento Territorio e Sistemi Agro-Forestali Università di Padova

DAFNAE Dipartimento di Agronomia Animali Alimenti Risorse naturali e Ambiente

In Supremæ Dignitatis 1343 Università di Pisa

Escuela de Ingeniería Eléctrica Pontificia Universidad Católica de Valparaíso

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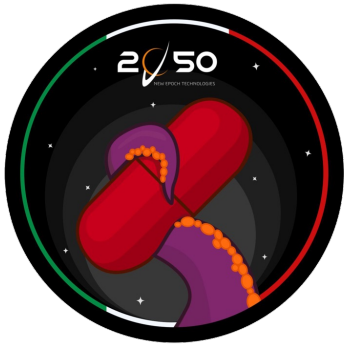
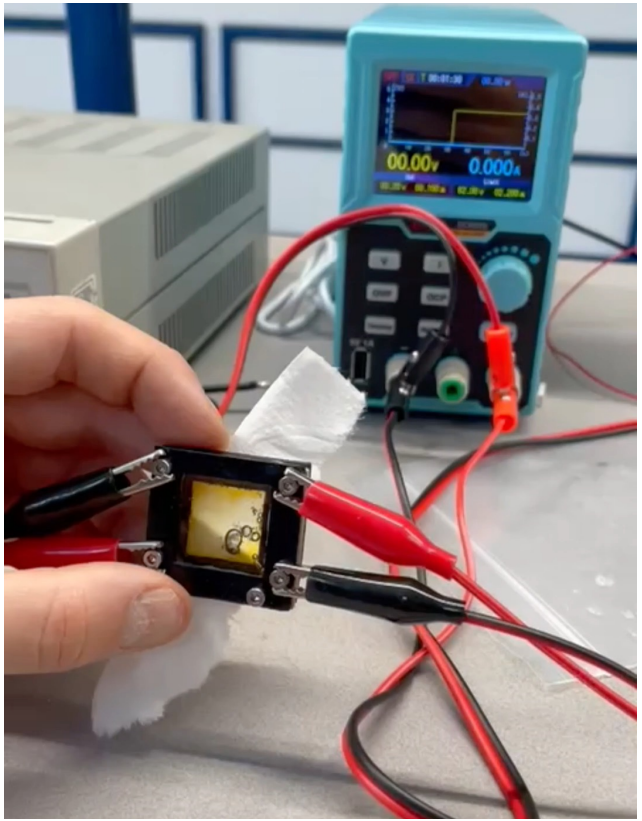
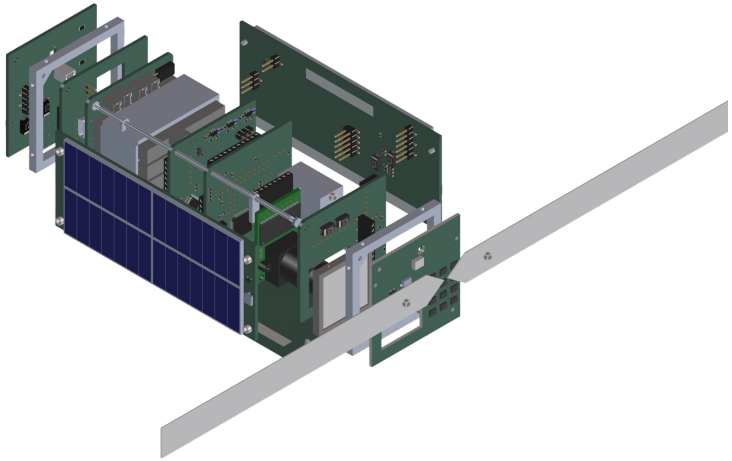
# Related projects







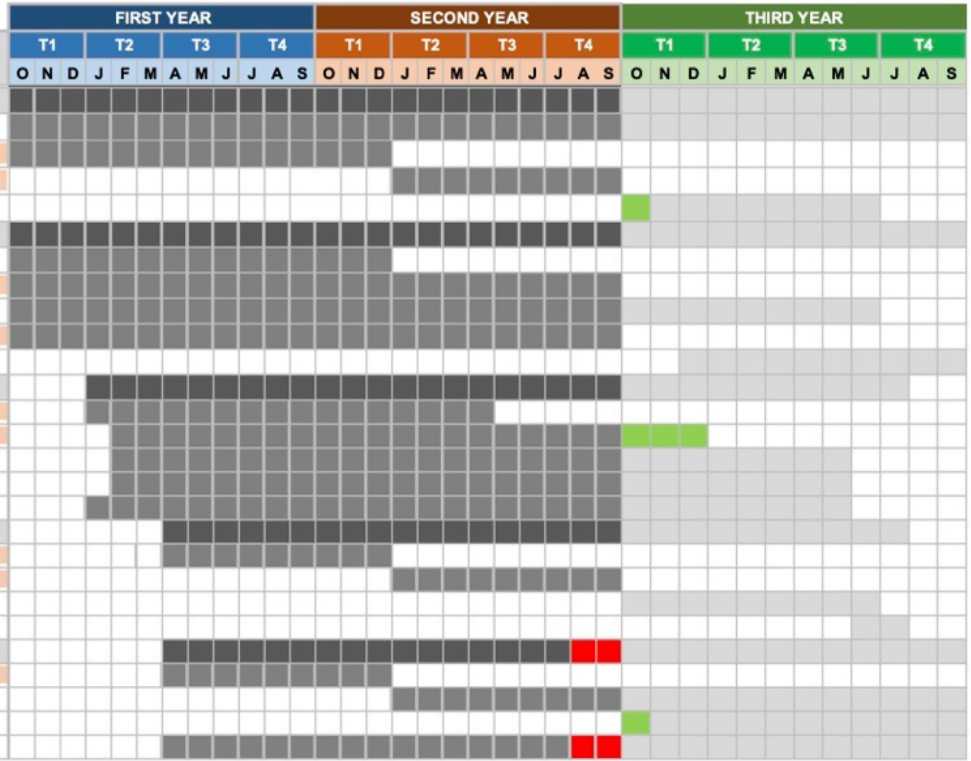

fly your satellite!



# GANTT Chart

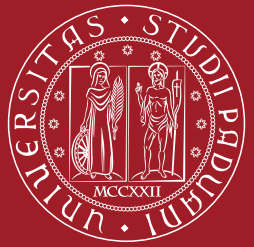


| WBS NUMBER | TASK TITLE | % OF TASK COMPLETE |
|---|---|---|
| 1 | Bibliographic Research | 65% |
| 1,1 | Today's technologies for Earth Observation | 65% |
| 1,2 | Precision agriculture strategies and indices | 100% |
| 1,3 | Light Pollution assessment strategies | 100% |
| 1,4 | Determination of Air pollution by Satellite | 12% |
| 2 | Earth Observation measurements know-how and technologies | 70% |
| 2,1 | Vegetation indices determination | 75% |
| 2,2 | Light Pollution sensor comparison | 100% |
| 2,3 | Air pollution sensor comparison | 75% |
| 2,4 | Cameras selection and comparison | 100% |
| 2,5 | Environmental measurements correlations | 0% |
| 3 | Prototypes development | 70% |
| 3,1 | Structure Design | 100% |
| 3,2 | 3D printing and rapid prototiping | 100% |
| 3,3 | Manufacturing and Integration | 75% |
| 3,4 | Prototypes alternatives and interfaces | 75% |
| 3,5 | Electonics and software development | 70% |
| 4 | Field tests | 66% |
| 4,1 | Crops monitoring | 100% |
| 4,2 | Light pollution assessment | 100% |
| 4,3 | Air Pollution Monitoring | 0% |
| 4,4 | Global device final testing | 0% |
| 5 | Data analysis and comparison | 60% |
| 5,1 | Vegetation Indices computation | 100% |
| 5,2 | Light pollution sources detection | 45% |
| 5,3 | Pollutant qualitative analysis | 10% |
| 5,4 | Satellite Data Comparison and correlation | 52% |



# Conclusions

- New configuration developed and field tested
- Data analysis of last test campaign and SAT data integration in progress
- Design, development and calibration of the Light pollution assessment payload for Chile flight campaign

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# Thank you for your attention

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