# MORERA: EARTH-OBSERVATION AND AI TECHNOLOGY AVAILABLE TO EVERY FARMER

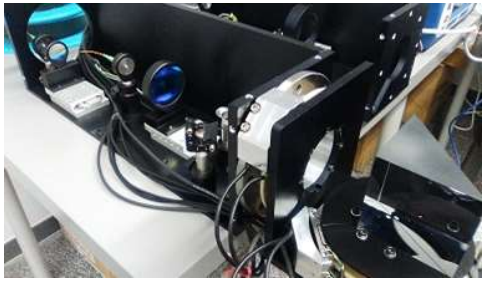
## INDUSTRALIZATION CHALLENGES

EPIC MEETING 21 – 22 SEPTEMBER

# ASE INTRODUCTION

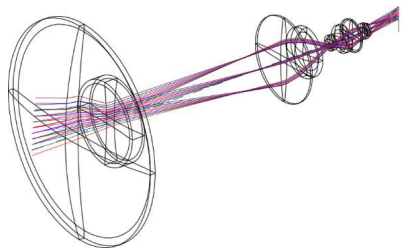
ASE Optics Europe developed a specific know-how for the design, engineering and production of complex and fully integrated optical, optoelectronic, laser and photonic systems for harsh environment applications thanks to the different projects developed for high-demanding applications and sectors:

## FUSION & NUCLEAR



## SCIENCE & RESEARCH


## DEFENSE



# GOING TO SPACE - SWIR OBJECTIVE ALREADY IN ORBIT

- SWIR Objective lens integrated into payloads for Earth Observation applications
  - Certified vacuum compatibility
  - Optically athermalized system
  - Stable polychromatic MTF within all operative temperature range -20ºC ÷ +40ºC
  - Common focus for two separate subwavebands

**Optical performance specifications**

| Parameter | Value |
|---|---|
| Wavelength | 1000 – 1700 nm |
| Sensor | 640x512 pixel x 15microns |
| Focal | 150mm |
| f/# | f/4,5 |
| MTF nominal | • Edge >60% Field >50% |
| MTF as built | • Edge >50% Field >40% |
| Transmission | 92% |
| Field distortion | <0,05% |
| Relative illumination | >92% |

**Mechanical parameters**

| Parameter | Value |
|---|---|
| Outside diameter | 46,5mm |
| Length | 141,25mm |
| Distance to the sensor | 12,20mm |
| Weight (max) | 265gr |
| Housing | Coated Aluminum |

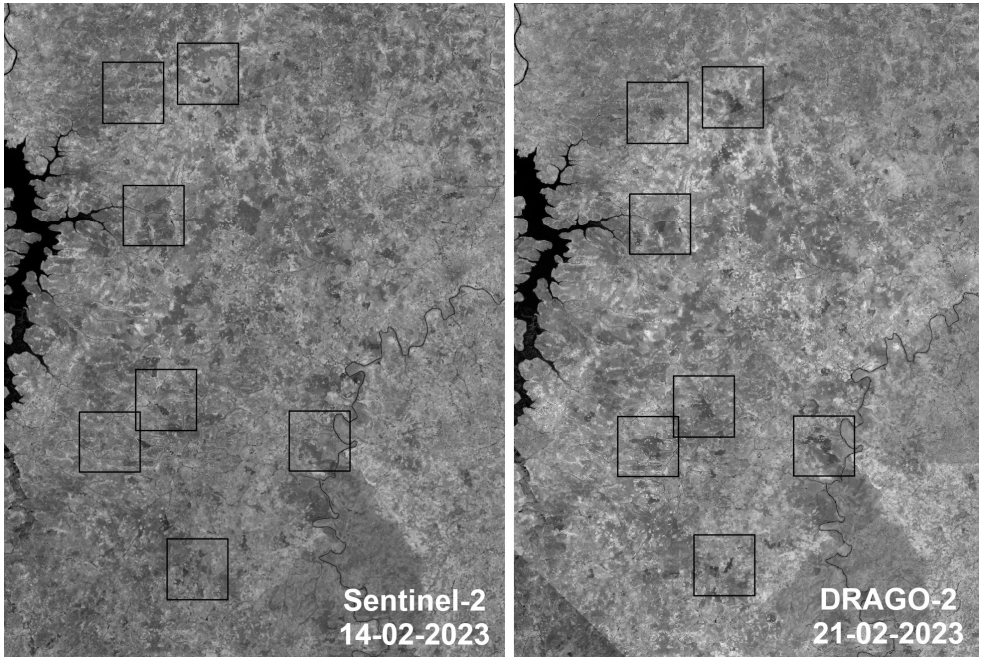
*ASE Optics has managed to design and build a customized infrared lens that did not exist on the market, robust for use in space and with dimensions and weight that enable it to be used on small satellites.*

**Alfonso Yñigo, systems engineer of IACTEC-Space**

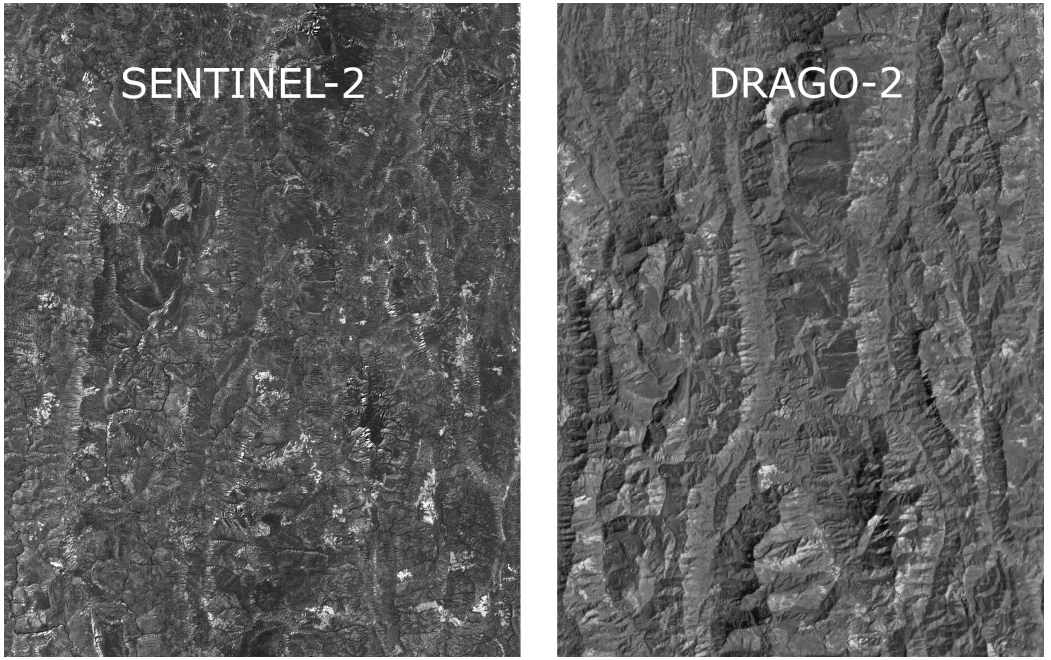
# SWIR OBJECTIVE – FIRST IMAGES, COMPLETE SUCCESS

*"DRAGO-2 has a different, and more complex objective lens, with a focus six times as long, which gives it much higher resolution".*

***Alba Peláez, optical engineer at IACTEC-Space***




Comparison between the images from Sentinel-2 and DRAGO-2, which show the development of forest fires, and the initiation of new outbursts in Mali, between 14th and 21st February 2023. The squares show the burnt zones. Credit: IACTEC.




Comparison between the images from Sentinel-2 and DRAGO-2 of the State of Mizoran, India. Credit: IACTEC.

*ASE Optics has managed to design and build a customized infrared lens that did not exist on the market, robust for use in space and with dimensions and weight that enable it to be used on small satellites.*

**Alfonso Yñigo, systems engineer of IACTEC-Space**

# MORERA INTRODUCTION

- Sustainable agriculture
  - Agriculture is the main Spanish industry (11% GDP)
  - Irrigated agriculture is the main consumer of water (In 2016, it consumed 70% of available water)
  - It produces 59% of food with only 25% of agricultural area so, it is a basic pillar for food security
  - Production is linked to highly fluctuating Mediterranean rainfall and irrigation is essential to ensure stable yields

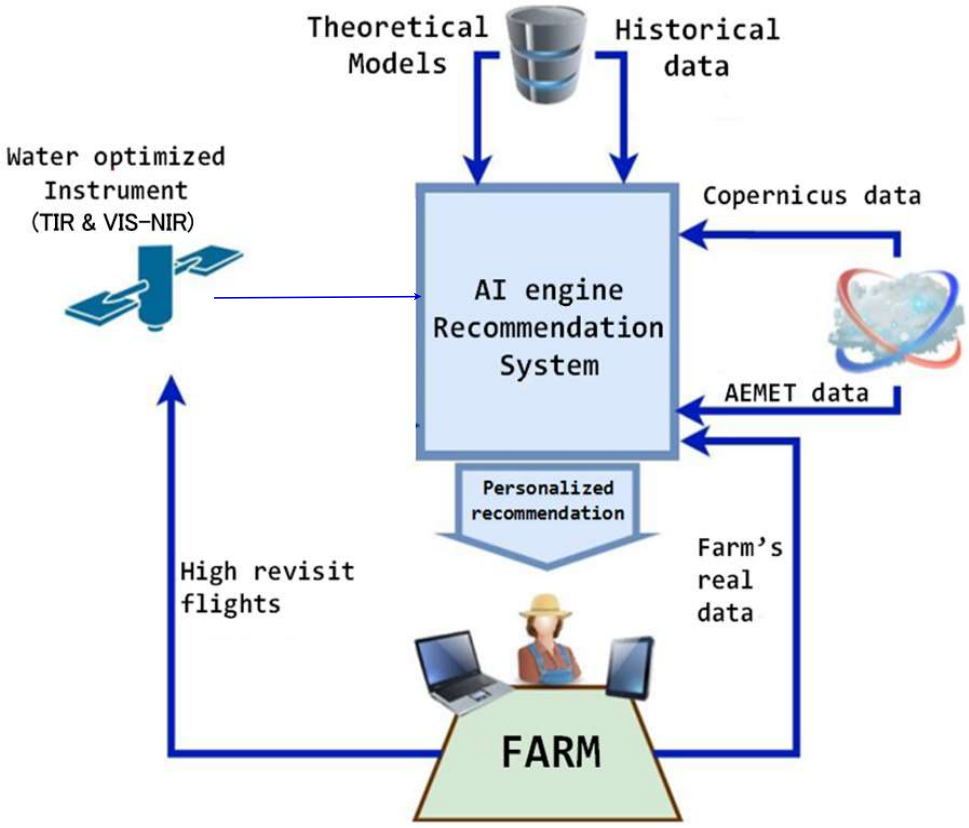
**PRODUCTIVITY OF IRRIGATION WATER MUST BE IMPROVED → Deficit Irrigation: "more crop per drop"**

- CDTI Missions Science and Innovation program
  - New program targeting solutions for deep social problems through innovation
  - Huge data available, but impossible to be used by non-experts
  - Personalized outputs taking into account user particularities and multiple data sources
  - Optical, optomechanical and electronic design
  - Algorithms for image processing

MORERA ThalesAlenia Space a Thales / Leonardo company

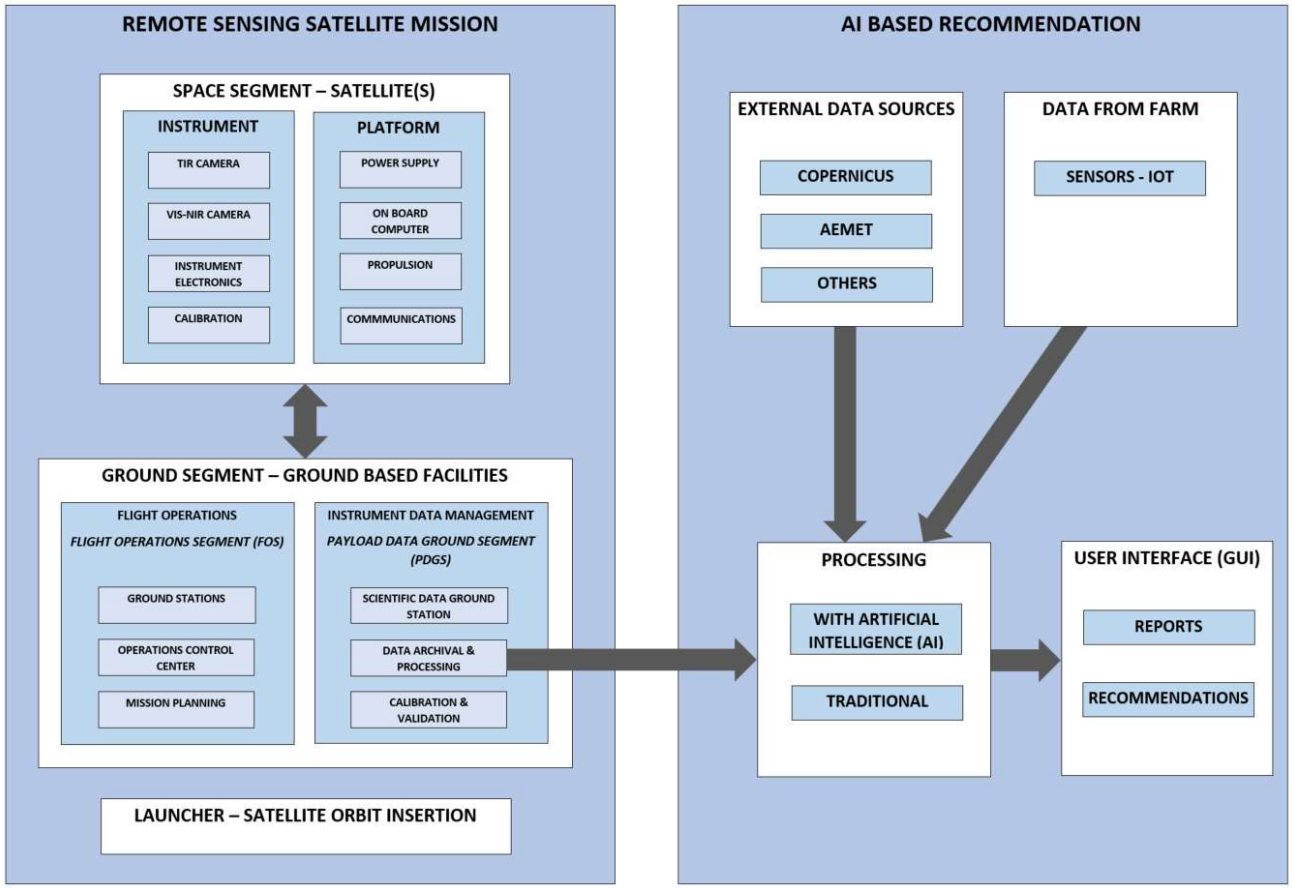
# MORERA SYSTEM: FROM SENSOR TO THE CROP

- MORERA Architecture Characteristics
  - Modular and scalable system
  - Artificial Intelligence core with Big Data integration capabilities
  - Data fusion: Copernicus, remote sensing, AEMET, sensors in field, historical data, etc.
  - Personalized & User-friendly application with added value (at Farm level)
  - New Space compact instrumentation for remote sensing

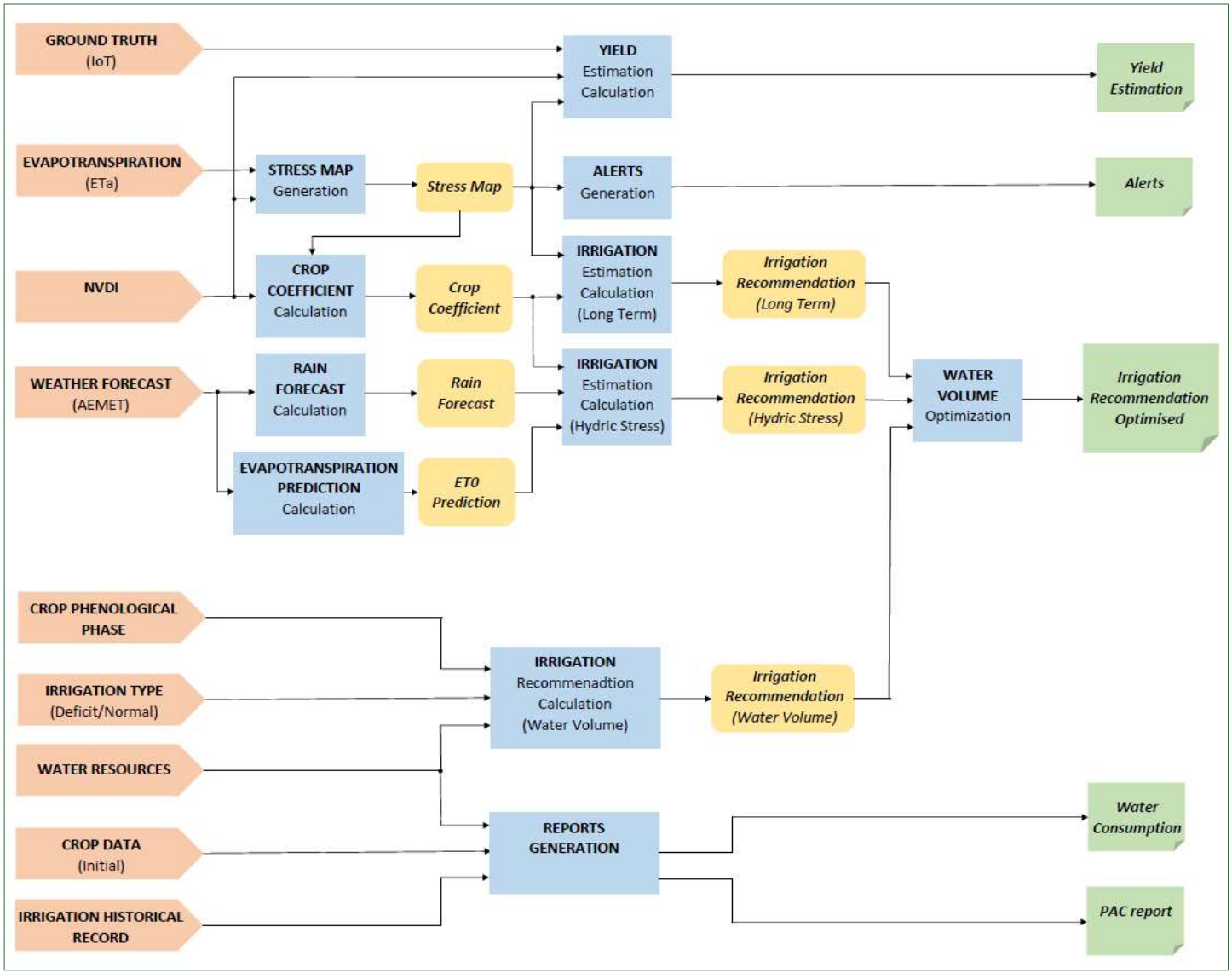


# PROCESS OVERVIEW

- Inputs derived from
  - Ground data (IoT)
  - Satellite data (Eta, NVDI)
  - State Meteorological Agency
  - Crop status/data
  - Water available
  - Irrigation records
- Outputs
  - Recommended Irrigation
  - Yield estimation
  - Alerts
  - Others



# DATA FLOW


GROUND TRUTH (IoT)
EVAPOTRANSPIRATION (ETa)
NVDI
WEATHER FORECAST (AEMET)
CROP PHENOLOGICAL PHASE
IRRIGATION TYPE (Deficit/Normal)
WATER RESOURCES
CROP DATA (Initial)
IRRIGATION HISTORICAL RECORD
YIELD Estimation Calculation
STRESS MAP Generation
Stress Map
ALERTS Generation
CROP COEFFICIENT Calculation
Crop Coefficient
IRRIGATION Estimation Calculation (Long Term)
RAIN FORECAST Calculation
Rain Forecast
IRRIGATION Estimation Calculation (Hydric Stress)
EVAPOTRANSPIRATION PREDICTION Calculation
ET0 Prediction
IRRIGATION Recommenadtion Calculation (Water Volume)
REPORTS GENERATION
Irrigation Recommendation (Long Term)
Irrigation Recommendation (Hydric Stress)
Irrigation Recommendation (Water Volume)
WATER VOLUME Optimization
Yield Estimation
Alerts
Irrigation Recommendation Optimised
Water Consumption
PAC report

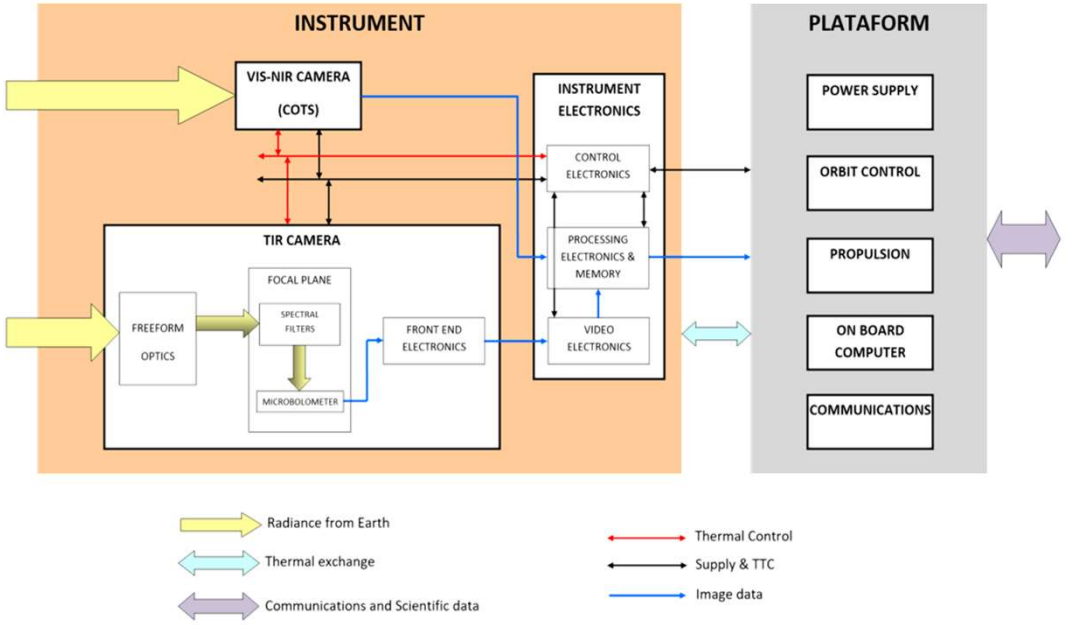
# NEW COMPACT AND HIGH-PERFORMANCE INSTRUMENTATION

- New Space for unprecedented performance/compactness

  S-SEBI demands non-existing TIR instrument in terms of:
  - Compactness (12U/16U cubesat platform compatible)
  - High resolution (<50 m @ 523 km orbit with 50 km swath)
  - High radiometric performances (NETD<0,5K)
  - High and flexible Re-visit time (low-cost constellation)

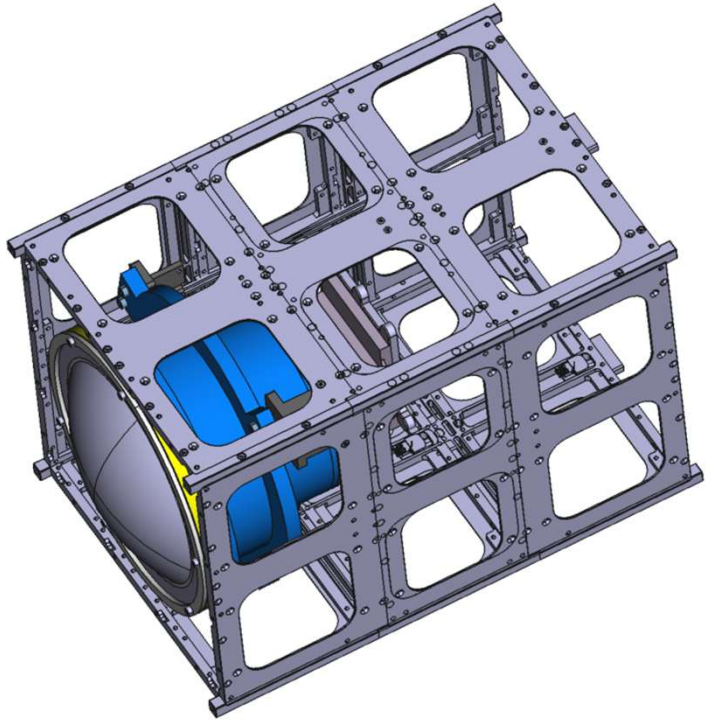
- Future large satellites (LSTM, Trishna) can provide high quantity and quality TIR & VNIR data.

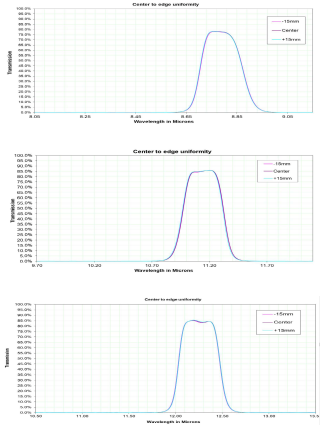
- Specific needs of some end-users can be covered by MORERA → COMPLEMENTARY to future large TIR missions.

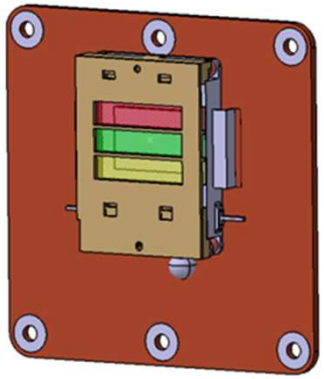


# TIR INSTRUMENT ARCHITECTURE

- LWIR objective
  - EFL 170mm
  - f/1.1
- NUC mechanism
- Filters subassembly
  - 3 subwavebands: 12.25, 11.0 & 8.8 µm
  - 3 lines 4.2 x 32.2mm
- FPA
  - Uncooled LWIR detector 1024x768x17 µm





# LWIR OBJECTIVE

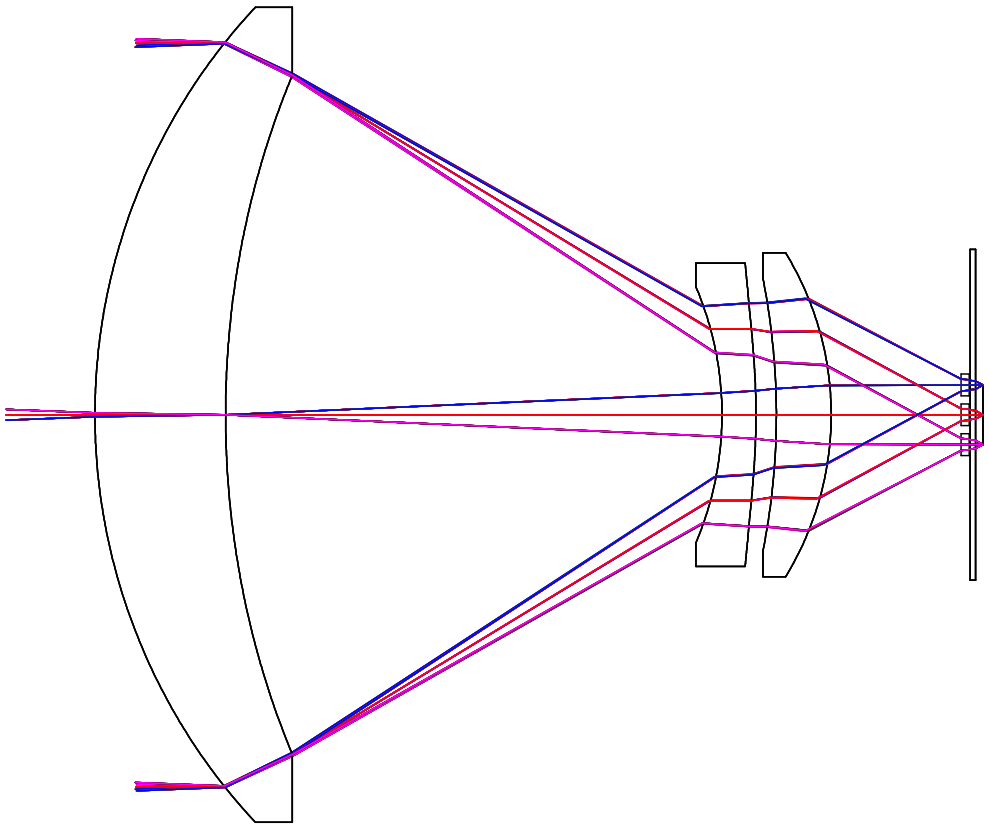
EFL – 170 mm → 148.8 mm
f/n – f 1.1 → f/1.045

3 lenses – material: BD6 or equivalent
- L1 aspheric & diffractive
- L2 aspheric
- L3 conventional

Transmission including filters > 75%
F-tan
Distortion < 2%
Telecentricity < 1°

Total track – 170 mm
Back focal length – 25 mm

Athermalization 20°C ±3°C

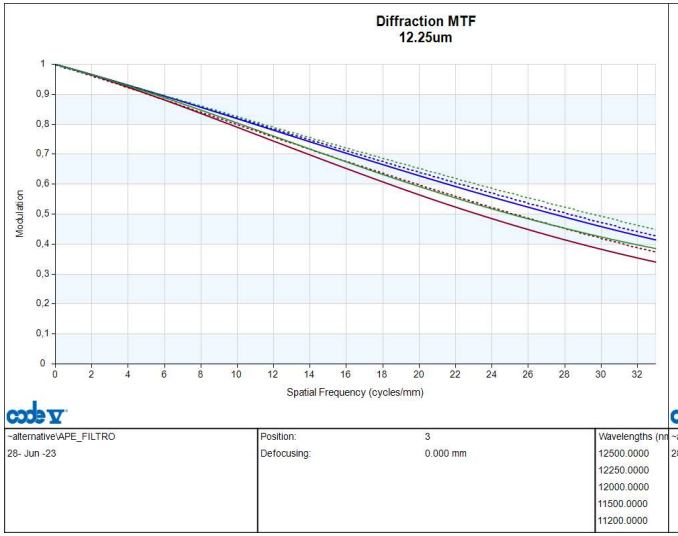


# LWIR OBJECTIVE PERFORMANCE

12.25 µm

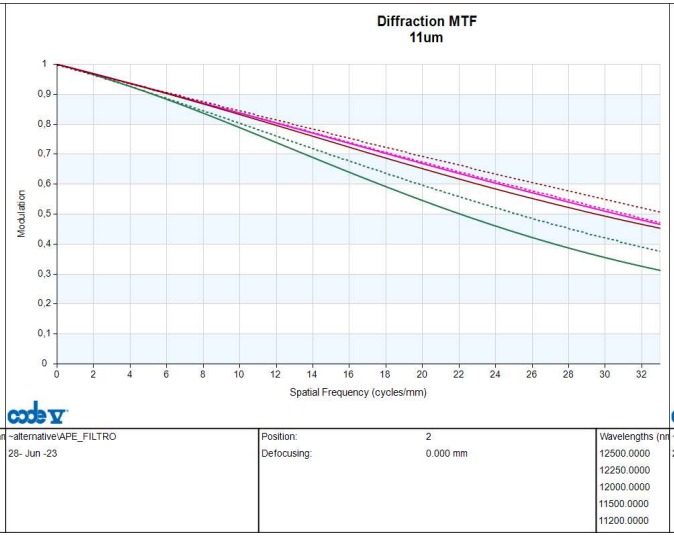
11.0 µm

8.8 µm



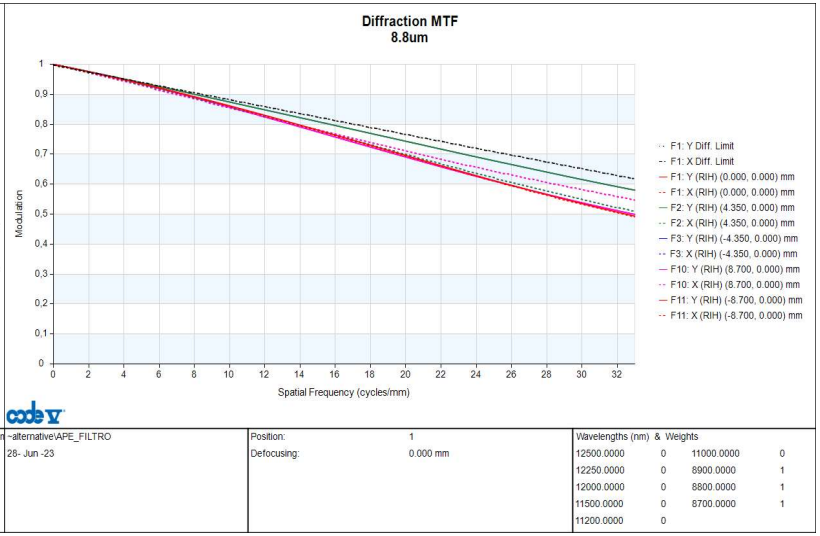

| | | |
|---|---|---|
| ~alternative\APE_FILTRO | Position: | 3 |
| 28- Jun -23 | Defocusing: | 0.000 mm |

| Wavelengths (nm |
|---|
| 12500.0000 |
| 12250.0000 |
| 12000.0000 |
| 11500.0000 |
| 11200.0000 |




| | | |
|---|---|---|
| ~alternative\APE_FILTRO | Position: | 2 |
| 28- Jun -23 | Defocusing: | 0.000 mm |

| Wavelengths (nm |
|---|
| 12500.0000 |
| 12250.0000 |
| 12000.0000 |
| 11500.0000 |
| 11200.0000 |




| | | |
|---|---|---|
| ~alternative\APE_FILTRO | Position: | 1 |
| 28- Jun -23 | Defocusing: | 0.000 mm |

| Wavelengths (nm) | & | Weights |
|---|---|---|
| 12500.0000 | 0 | 11000.0000 0 |
| 12250.0000 | 0 | 8900.0000 1 |
| 12000.0000 | 0 | 8800.0000 1 |
| 11500.0000 | 0 | 8700.0000 1 |
| 11200.0000 | 0 | |

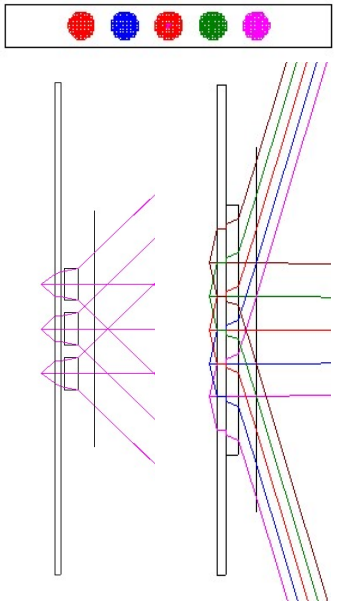
# NUC MECHANISM

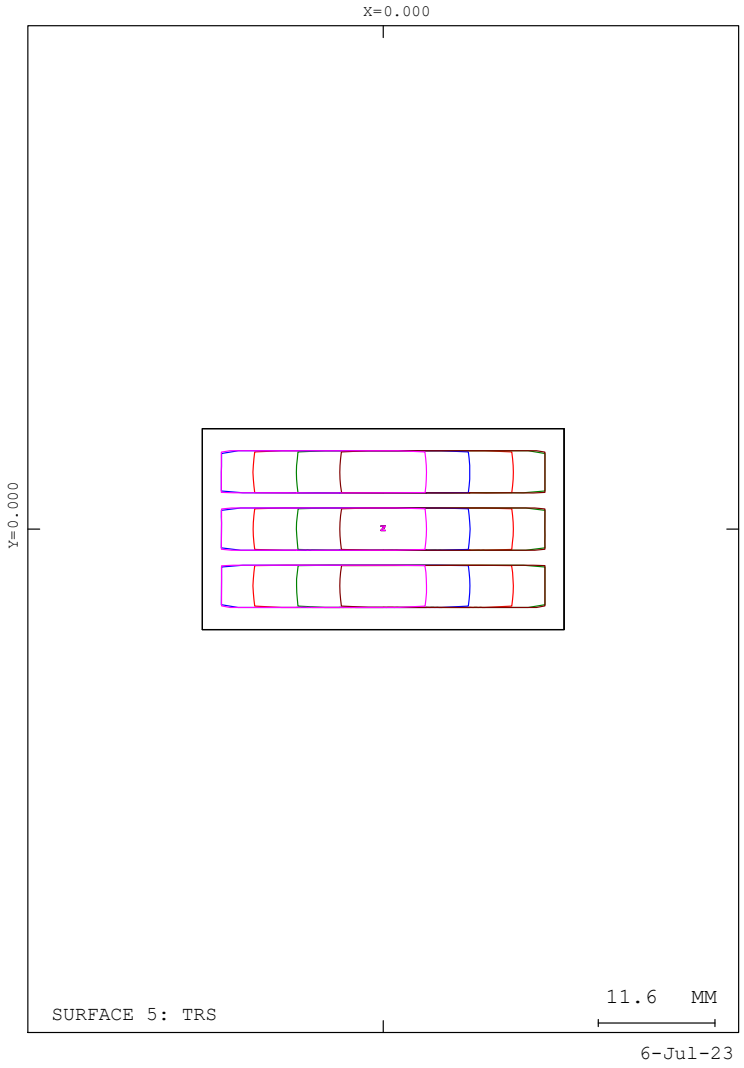
Non-Uniformity Correction (NUC) in flight

TEC peltier blackbody or an IR shutter in front of the sensor @ 2.5mm

FOV sampling – each filter line-FOV

Footprint @ TRS 20x36mm





# INDUSTRIAL NEEDS

- TRS development
  - COTS units to be developed for actual dimensions

- Platform adaptation
- Some potential small platforms have been identified, but detailed accommodation and trade-off has to be performed for the business case and mission

- Mechanics
  - Space-qualified low emissivity painting

- Optics Manufacturing
  - Chalcogenide BD6 or equivalent blank > 200x60 mm
  - Lens manufacturers with DT capabilities for BD6
  - Space-qualified high transmission AR coatings

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