DESIGN AND TEST OF AN OPTICAL DAYLIGHT TRACKING CAPABILITY FOR LEO, MEO, GEO

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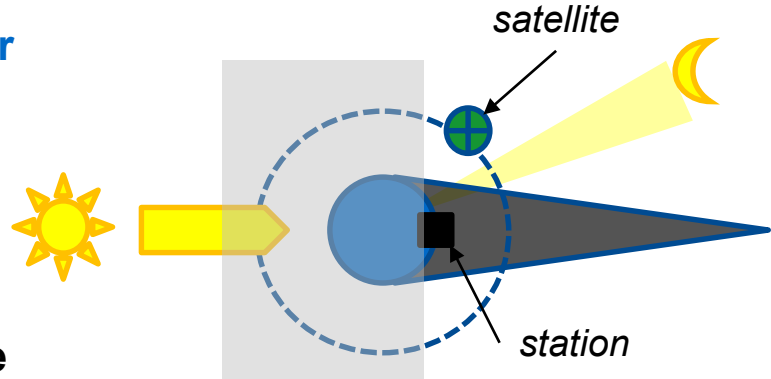
CONTEXT

- **GEOTracker© network : 14+ optical tracking and survey sensors around the world**

- **Optical sensors constraints**
  - Clear sky
  - Station at nighttime
  - Object illuminated by the Sun

- **Limited observation opportunities, in particular for LEO objects**

- **Stations overloaded at night, unused during the day**

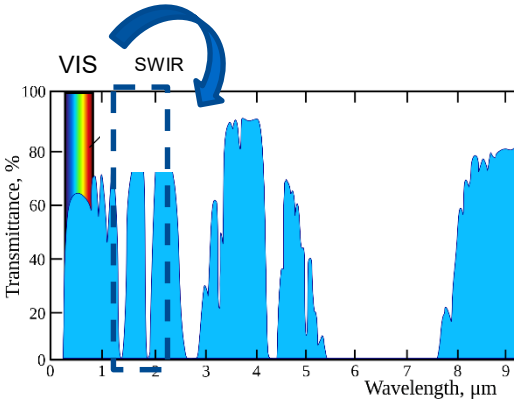


→ ArianeGroup investigates the feasibility of daytime observation

CHALLENGE & SOLUTION PROPOSED

- **Observing at daytime → sensor saturation**
- **Solution proposed**

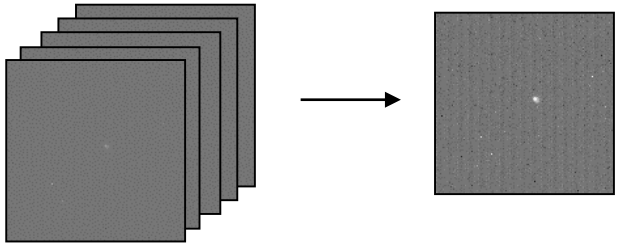
Switch to SWIR (Short Wave InfraRed)



Atmospheric transmittance

Adapt the acquisition strategy and post processing

Short exposure images cumulation

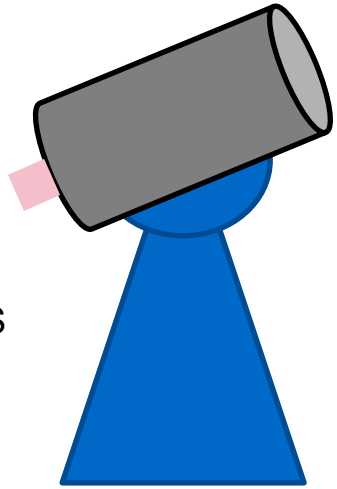


SNR (Signal to Noise Ratio) improvement

→ The idea is to experiment the solution on existing observation station

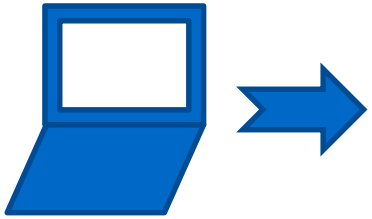
EXPERIMENTAL SETUP

Optical tracking station
Including COTS SWIR camera



Acquisition strategy

Image processing algorithms (internal development)



Raw images

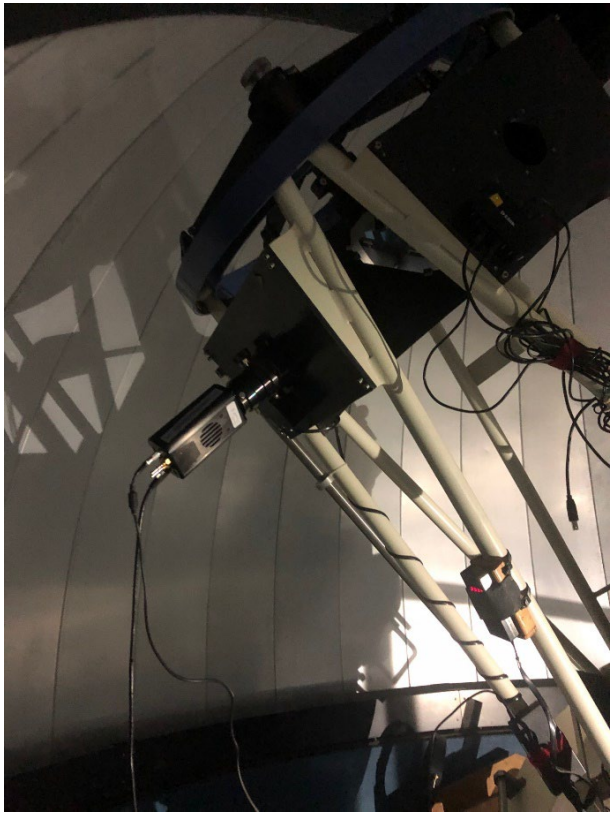
Image pipe

Angular measurements (RA, DEC)

OPTICAL CONFIGURATION #1

GEO campaign configuration

- 60cm Newton telescope
- Cooled InGaAs SWIR camera
- Waveband : 0,9µm – 1,7µm
- Equatorial mount (low tracking speed)
- St Michel L'Observatoire (France)



OPTICAL CONFIGURATION #2

MEO/LEO campaign configuration

- 35cm COTS telescope
- Cooled InGaAs SWIR camera
- Waveband : 0,9µm – 1,7µm
- Alt-az mount (high tracking speed)
- Issac (France)

EXPERIMENTATION PLAN

GEO

- Choice of 10 satellites visible from the station
  - Various magnitudes (as estimated by GEOTracker© network in visible wavelength)
  - Various pointing directions
  - Various types of platforms
  - Sequential observations for solar elevations between -15° and +15° (dawn and dusk)

MEO

- Observation of GNSS satellites and rocket bodies, depending on opportunities
- Solar elevations between -15° and +15° (dawn and dusk)

LEO

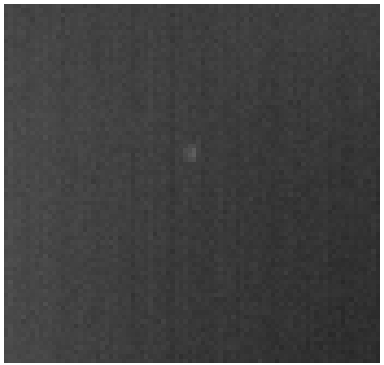
- Any object in visibility of the station
- Full daytime

RESULTS ON GEO SATELLITES

Detection proved for solar elevation up to 14,7° (for bright satellite)

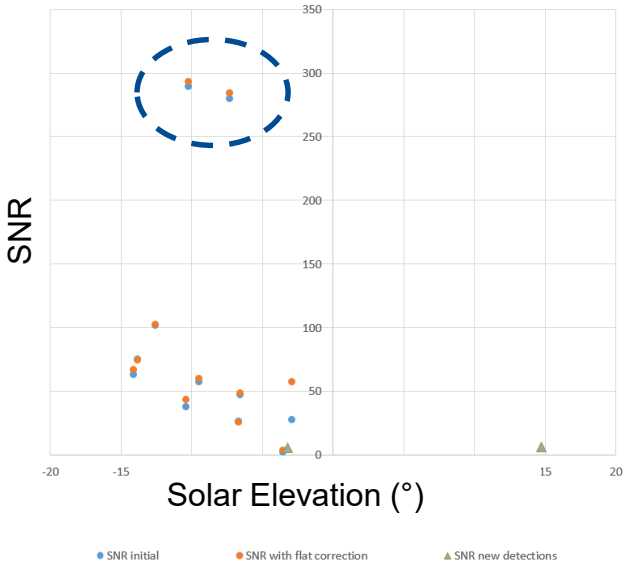
Identification of most favorable geometric configurations

- At dawn for satellite at azimuth >180°
- At dusk for satellite at azimuth <180°



Zoom on image obtained of GEO satellite for solar elevation = 14,7°

SNR vs solar elevation – same satellite



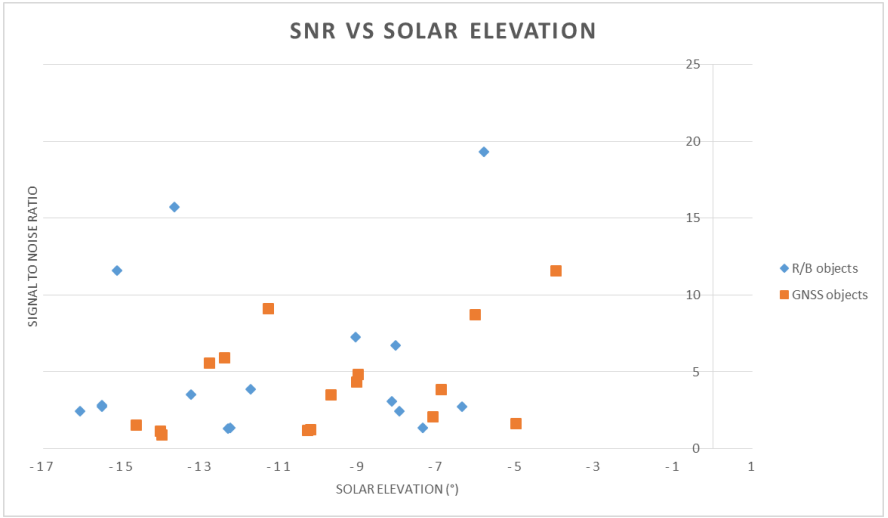
RESULTS ON MEO SATELLITES

Detection proved for solar elevation up to -4°

- MEO satellites are usually fainter than GEO
- Instrument used is less sensitive

No obvious trend on SNR variation

- Intrinsic magnitude of the objects and influence of phase angle not taken into account
- No magnitude reference for objects observed

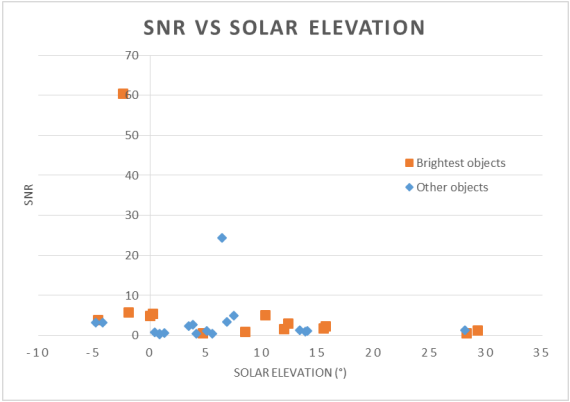


→ Possibility to extend the observation periods by a few hours per day

RESULTS ON LEO SATELLITES

Detection proved for solar elevation up to 30° (close to maximum solar elevation in winter)

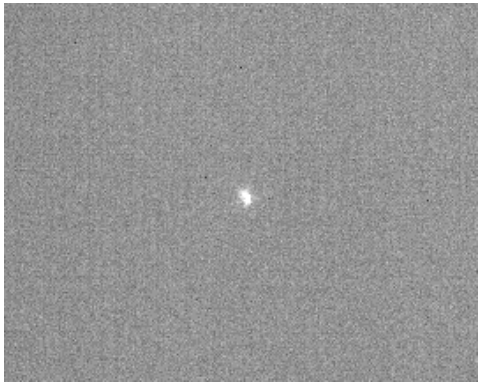
- LEO satellites are usually bright
- Good results obtained, even on satellites not flagged as “brightest”



Sensitivity is difficult to assess precisely

- No magnitude reference available for the objects observed
- More tests would be required to assess the performance

→ Possibility to observe 24/24



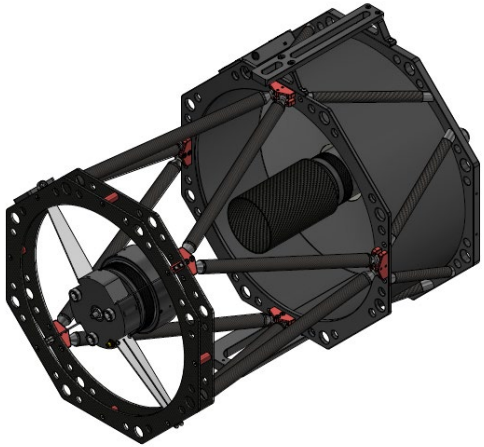
Zoom on image obtained of a LEO satellite solar elevation = 28°

CONCLUSION & WAYFORWARD

Daytime detection proved with COTS-based station and appropriate image processing

→ **Ability to extend the observation spans by few hours in MEO/GEO, 24H/day in LEO**

→ **Strong interest to optimize optical network performances, especially in LEO**



Performances could be improved with upgraded station

- IR optimized telescope
- Auto-exposure strategy
- Image processing optimization

Definition and industrialization of optimized IR station already in progress

- First IR stations to be included in GEOTracker© network in 2023

ACKNOWLEDGEMENTS

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Thank you for your attention !

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ANNEX

ANNEX 1 : CAMERA CHARACTERISTICS & OPTICAL CONFIGURATIONS

	COTS SWIR camera
Resolution (pixels)	640x512
Pixel pitch (µm)	15
RON (e-)	<30
DC (e/p/s)	<600
Max framerate (fps) (full frame)	600

	Configuration 1	Configuration 2
FOV (°)	0,23x0,20	0,15x0,12
Resolution (arcsec)	1,37	0,84
Collection diameter (cm)	60	35,5