SYSIPHE :

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Onera

ONERA

THE FRENCH AEROSPACE LAB

return on innovation

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SYSIPHE, an airborne hyperspectral imaging system

- **Airborne hyperspectral imaging system for defence/scientific research applications**

- **Full wavelength range (VNIR/SWIR/MWIR/LWIR) with ~500 bands**

- **Large swath and fine spatial resolution (500m, 0.5m @2000m)**

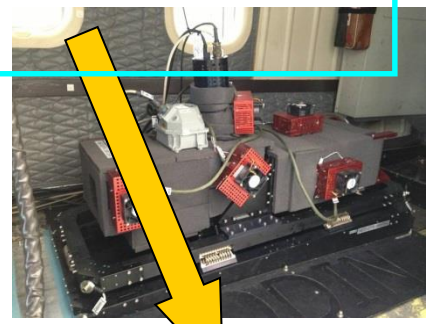
- **Sysiphe development consortium:**
  - Built by Onera (France), FFI (Norway) and NEO (Norway)
  - Supported by French and Norwegian MoDs

- **Development started in 2007, first flight in Fall 2013**

SYSIPHE components

Spectral imager
MWIR / LWIR
SIELETERS
(ONERA)

Spectral imager
VIS/SWIR
Hyspex Odin-1024
(NEO)



Real time image processing System (FFI/NEO)

Archiving and processing data system
STAD
(ONERA)

Products

- **Spectral reflectance / emissivity and temperature maps**
- **Spectral radiance**

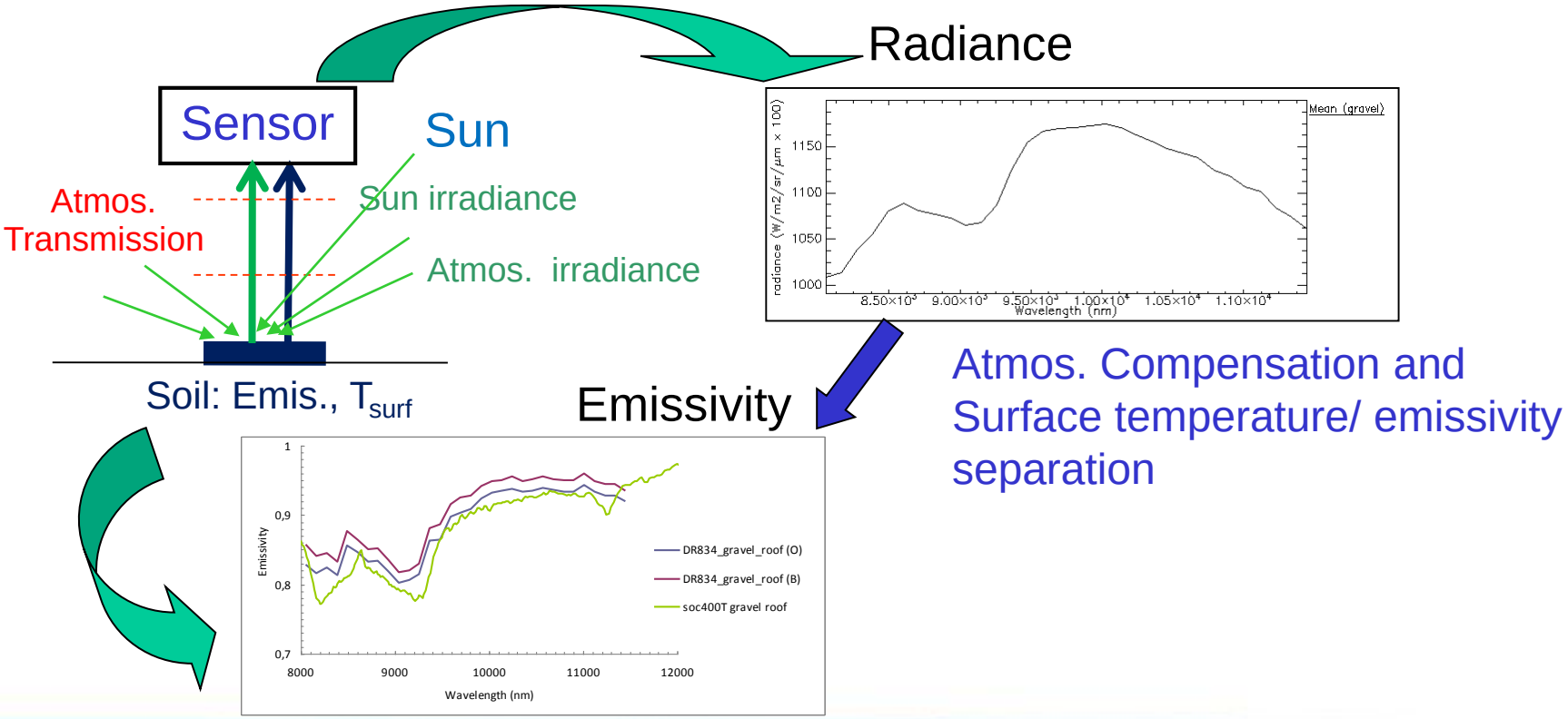
Calibrated & georeferenced

Archiving and processing data system (STAD)

The STAD will:

- register all the images delivered by the two instruments in a common georeferenced spectral image from VIS to LWIR;

- perform atmospheric compensation at all wavelengths.

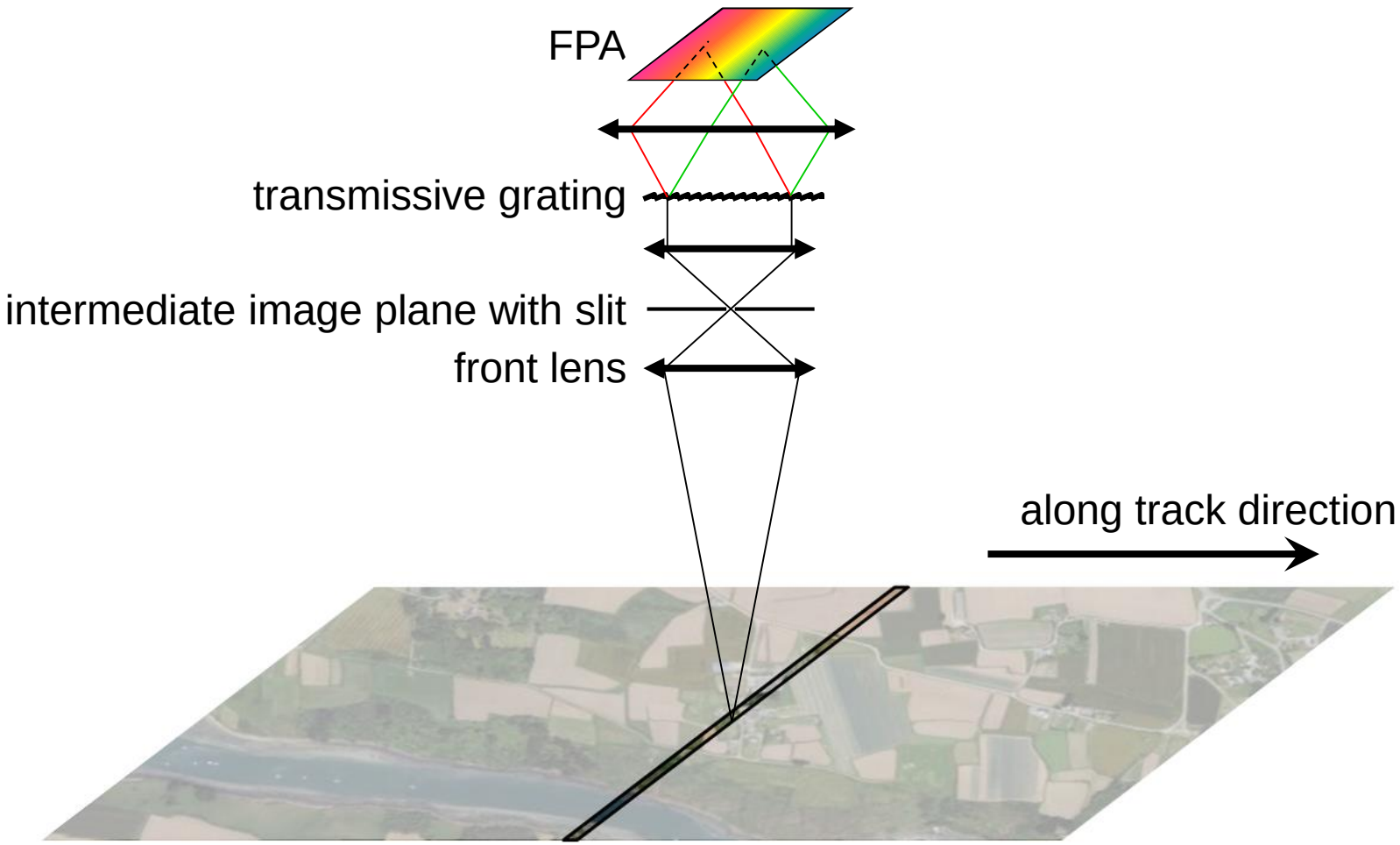


HySpex ODIN-1024 main characteritics

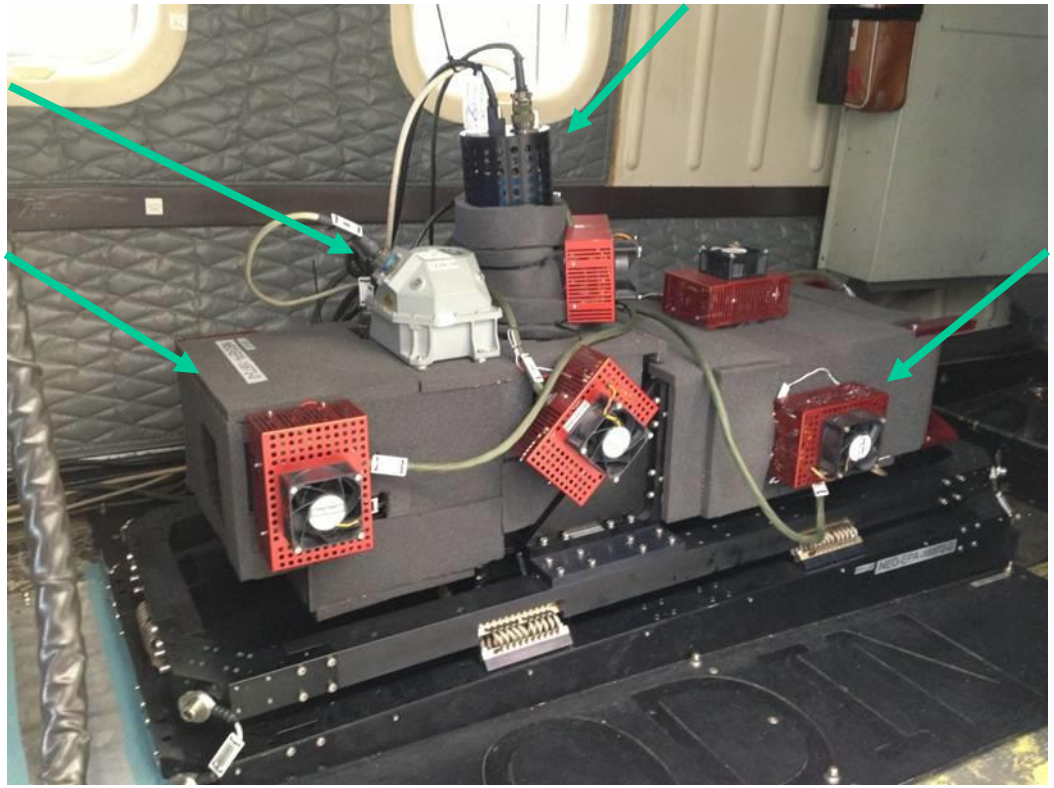
Parameter	VNIR	SWIR
Spectral range	400 – 1000 nm	950 – 2500 nm
Spectral resolution	5.0nm	6.1nm
Pixel FOV	0.25mrad	0.25mrad
Total across track FOV	15°	15°
Spatial resolution	1024px	1024px
F-number	F1.64	F2.0

- Consists of two pushbroom imaging spectrographs
- Common fore-optics to ensure perfect registration between VNIR and SWIR
- VNIR sensor has 2048 spatial pixels but is downsampled to 1024 pixels
- Low F-numbers for high throughput

HySpex ODIN-1024 acquisition mode



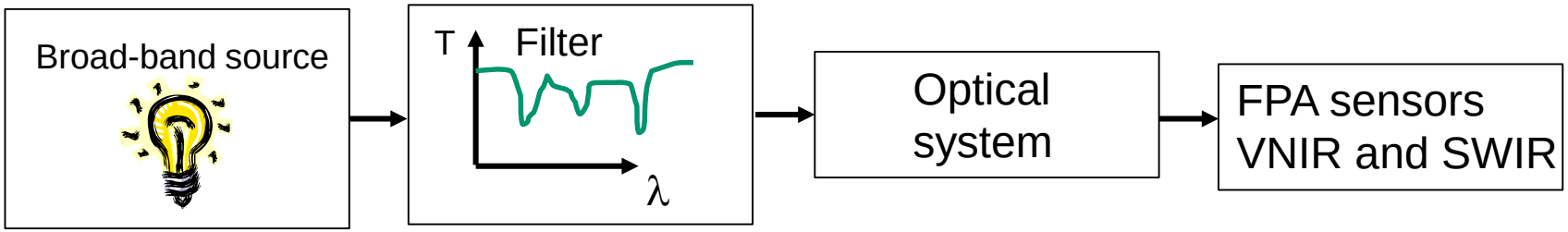
HySpex ODIN-1024 mounted in aircraft



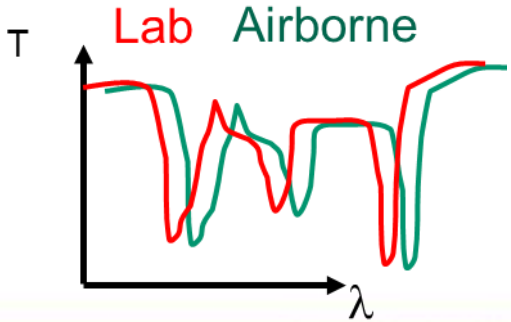
Rugged aluminum structure for high mechanical stability

HySpex ODIN-1024 on-board calibration facility

- Optical system may slightly change properties from laboratory to airborne operation
- Difference air pressure at different altitudes
- ODIN has facility to monitor changes



- Reference calibration measurement is done on-ground in Lab
- Airborne calibration measurement is made for comparison
- Camera shutter to outside world closed for calibration measures



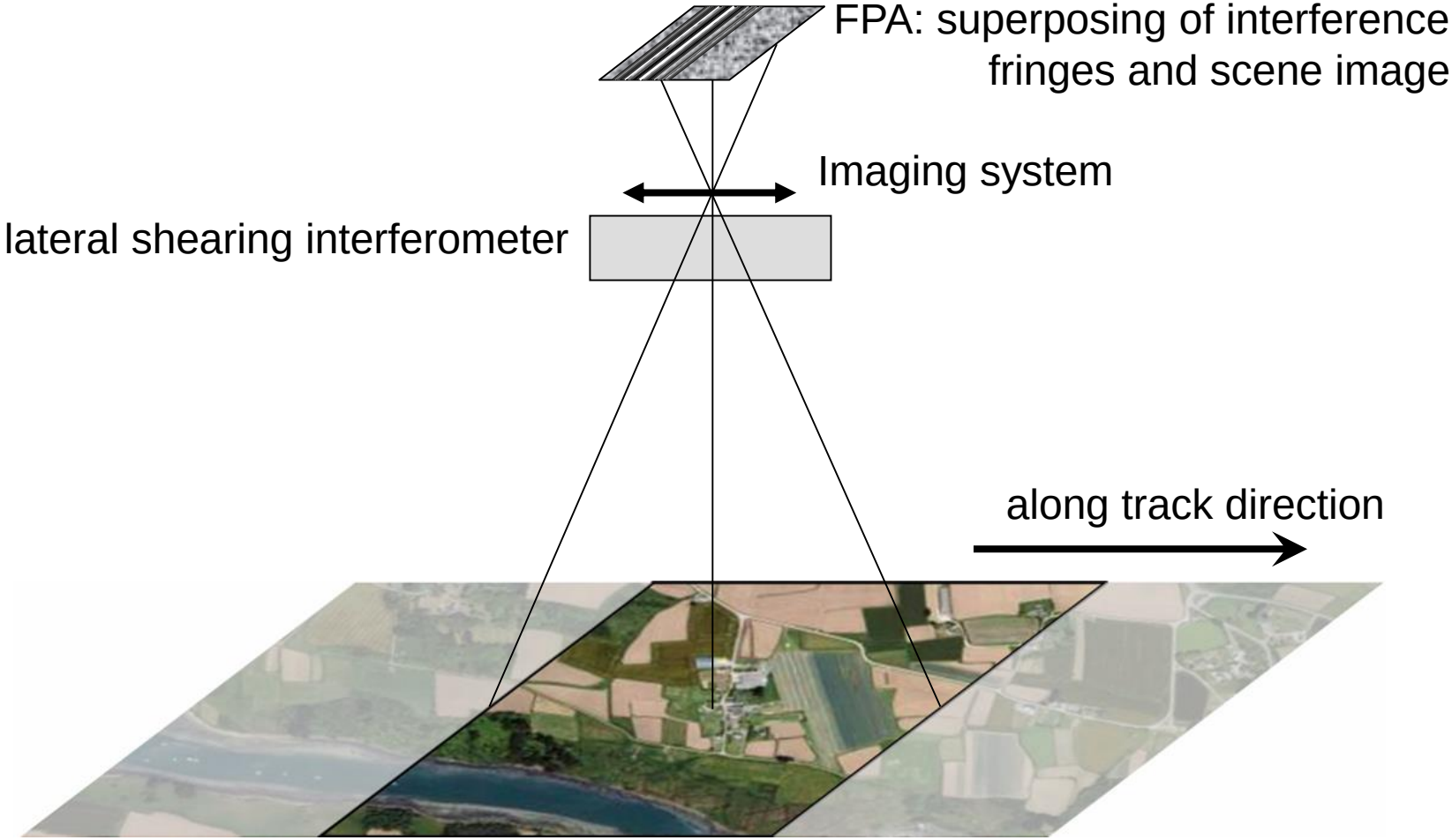
- Airborne actual images with shutter open can be adjusted to compensate for changes using onboard-calibration data

Sieleters main characteristics

Parameter	MWIR	LWIR
Spectral range	3.0 - 5.4 µm	8.1 – 11.8 µm
Spectral resolution	13 cm^{-1}	6 cm^{-1}
Pixel FOV	0.25mrad	0.25mrad
Total across track FOV	15°	15°
Spatial resolution	1016px	1016px
F-number	F4.0	F3.0

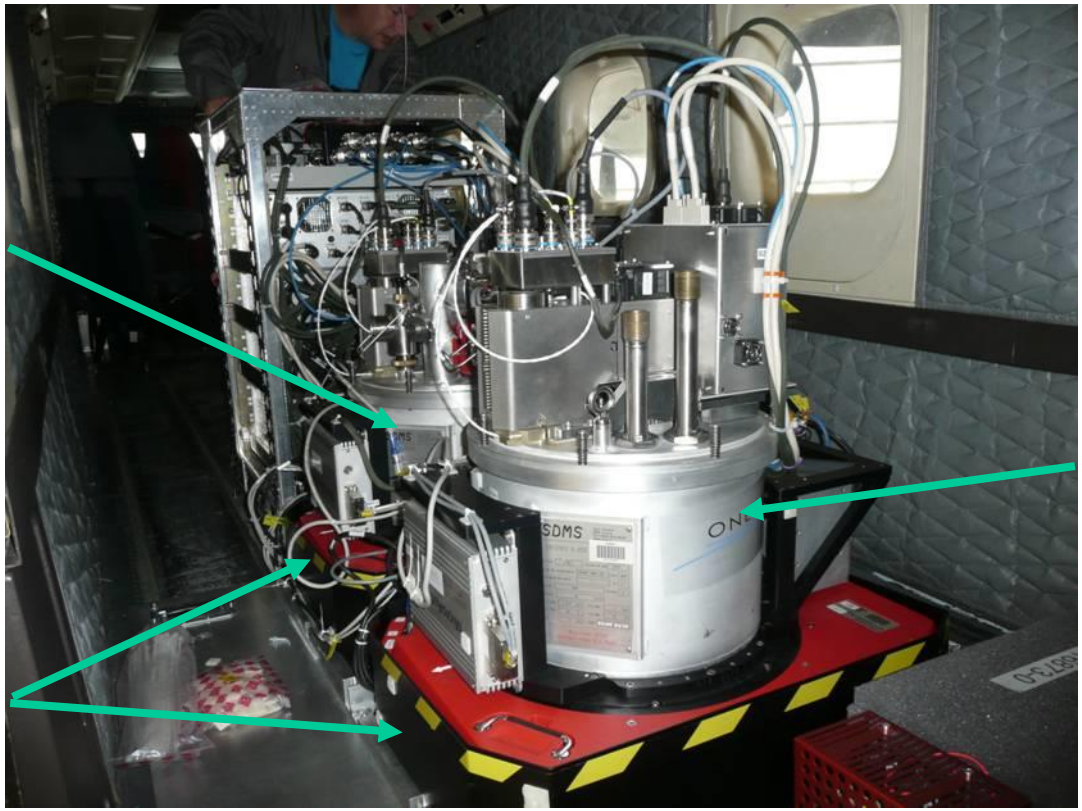
- Two separate static Fourier transform spectral imagers
- MCT IR-FPAs from Sofradir, 1016x440 pixels
- Entirely cryogenic (liquid nitrogen, 77K)
- Stabilized

Sieleters acquisition mode description



Sieleters mounted in the aircraft

flight direction



SYSIPHE first flight campaign: Cazaux, September 2013

- Aircraft: Do-228 from DLR (73m.s^{-1}, 2000m)
- 4 flights during 3 days :
Toulouse and Cazaux (Cobra IR pattern)

Cobra IR pattern (French airbase of Cazaux)

Cobra IR pattern (20x20m², ΔT~20°C)

patterns for VIS-NIR-SWIR images

Sieleters flight stabilization

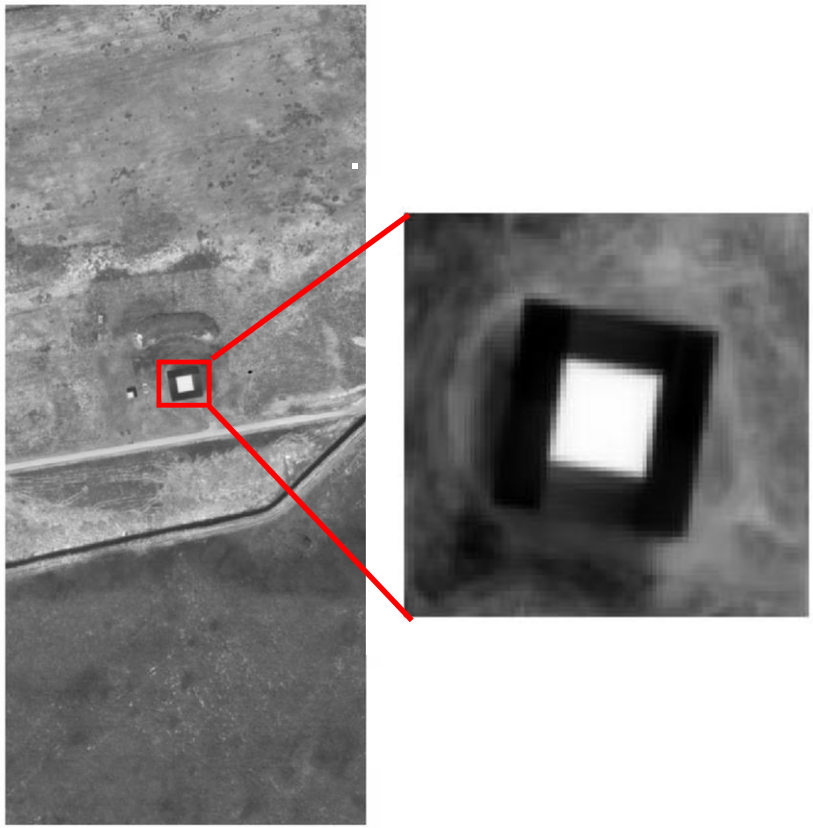
- Stabilization : < 90 µrad

- Control loop optimization : <1 pix. residual error over 440 images gliding window

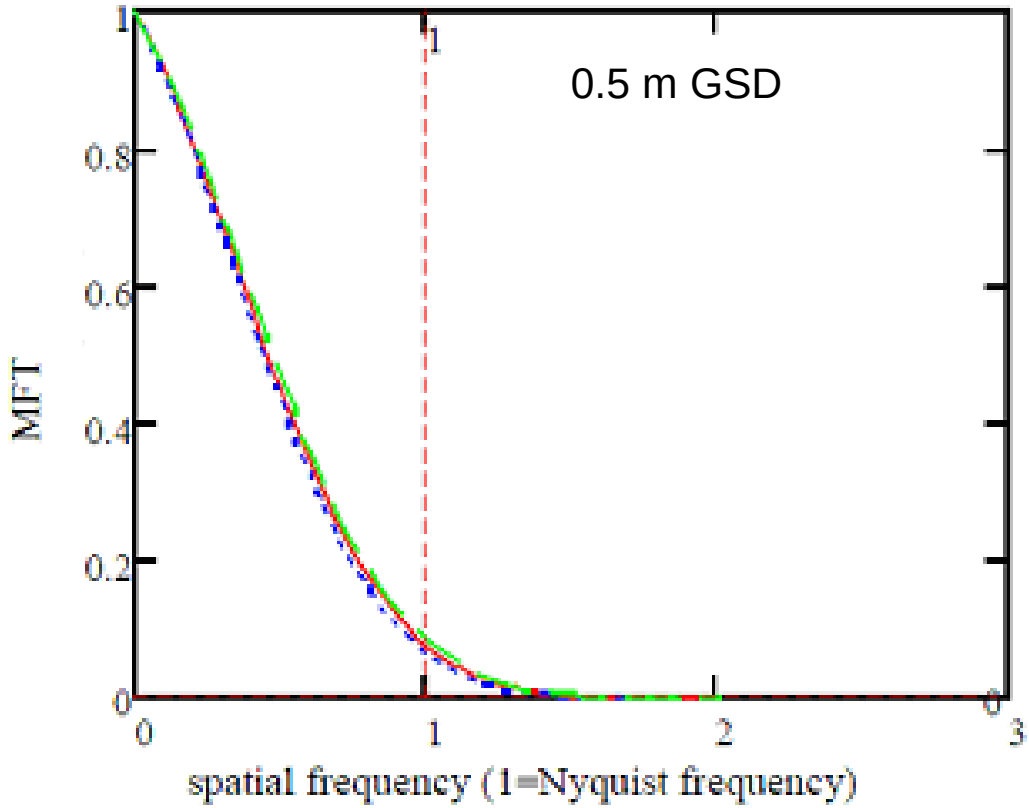
- Position (WGS84) : < 15 cm

Sieleters MTF flight measurements

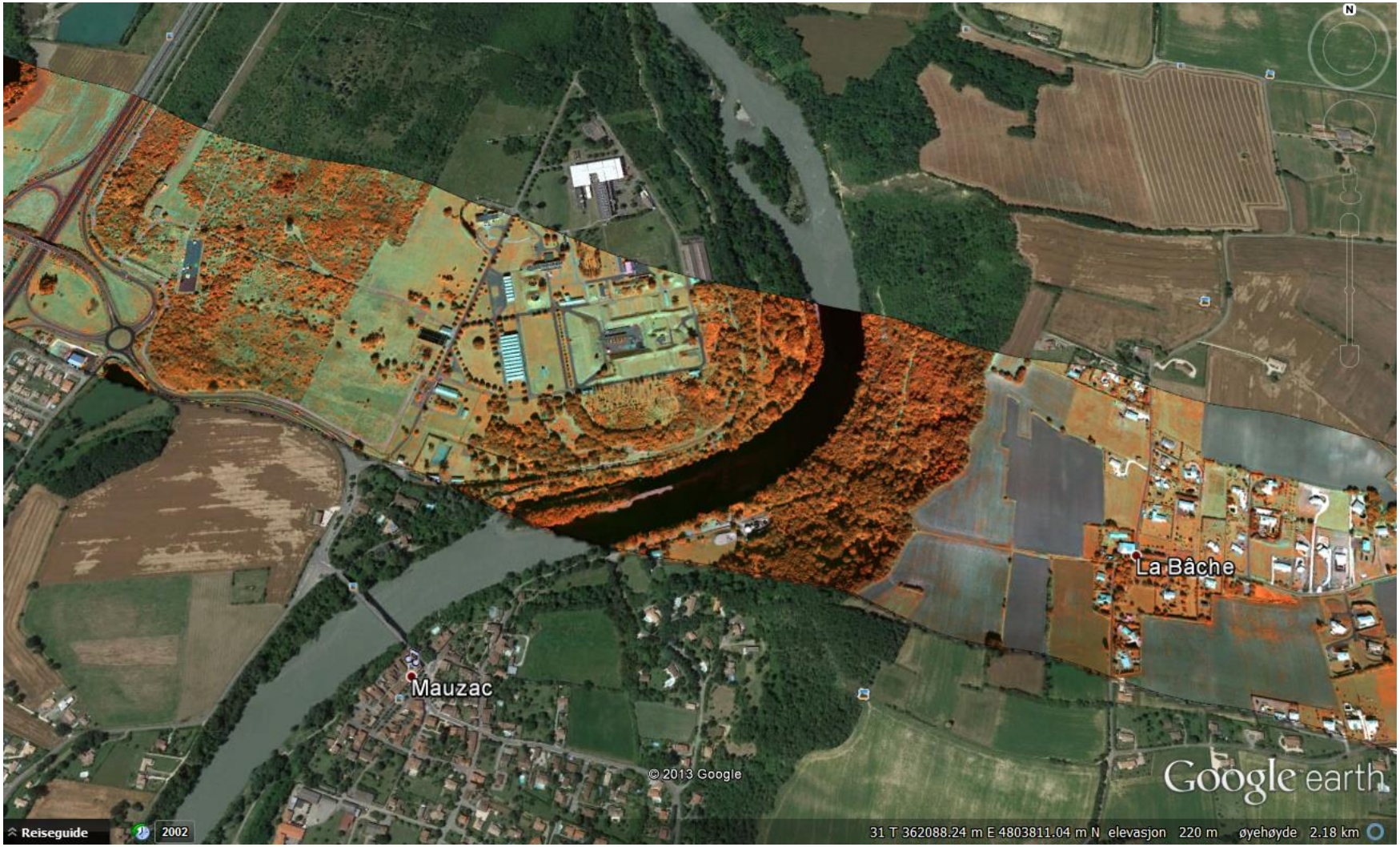
- MTF measurement on Cobra IR pattern
  - MTF @ 0.88 m^{-1} > 0.71 (>0.45 required)
  - MTF @ 0.33 m^{-1} > 0.22 (>0.10 required)



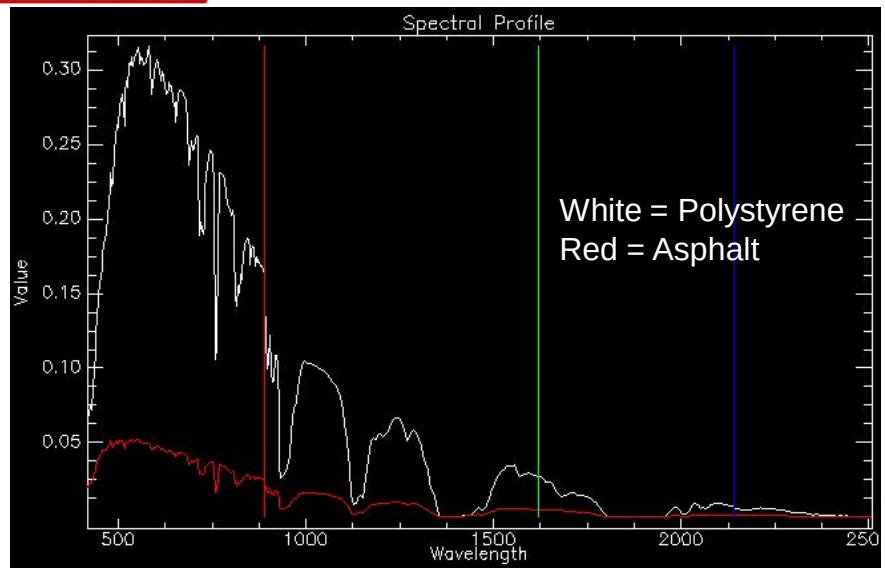
Sieleters panchromatic image



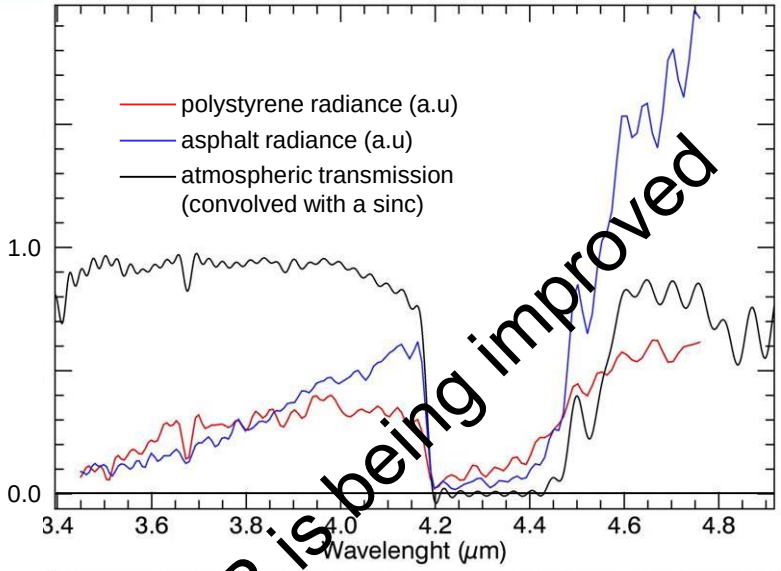
Orthorectified Hyspex-Odin-1024 image

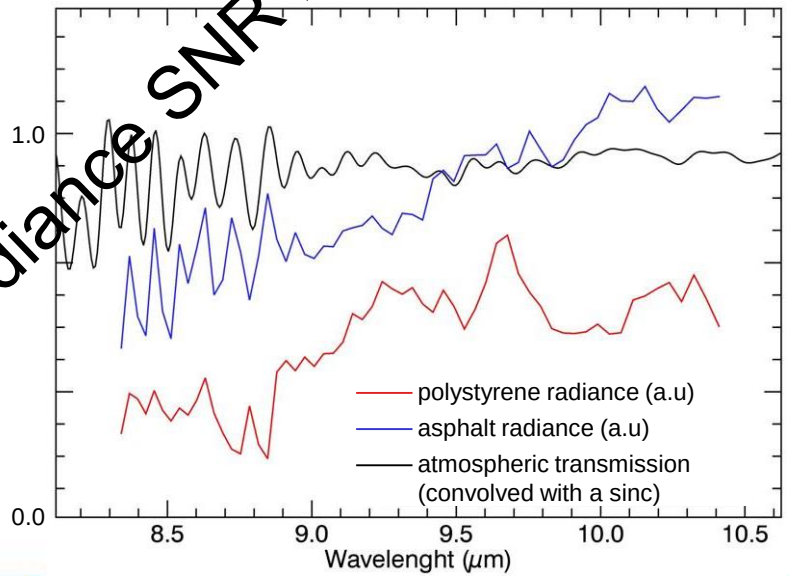


Hyspex-Odin 1024 first results



First Sieleters preliminary spectral results





Spectral radiance SNR is being improved

SYSIPHE conclusions

- Uniquely wide spectral area : **0.4 µm to 11.8 µm**
- **Very good SNR expected** (still to be flight validated)
- Very high spatial resolution : **500 m swath, 50 cm ground sampling pitch**
- **Integrated processing chain** will allow georeferenced products of spectral radiance, spectral emissivity/reflectance, and surface temperature (in progress)

SYSIPHE conclusions

- **First flight in September, 2013** (images being processed for instruments validation), acceptance expected for Summer 2014.

- **Sysiphe will then be open to external users:**
  - NATO, EDA or others
  - EUFAR, European Facility for Airborne Research
  - national and international community: scientific, industrial or institutional


Thank you for
your attention!
Contact.Sysiphe@onera.fr
DGA Essais en vol/photo site de Cazaux