The Indian-French TRISHNA mission

Local and global monitoring of our ecosystem health

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LSTM / TRISHNA

Scientific Objectives

LSTM primary objective

- **Evapotranspiration**

  Goal ***Threshold***

LSTM complementary objectives

- Mineralogy
- **UHI**
- High temperature events
- **Permafrost and frost damage**
- **Coastal management**

LSTM MRD 2.0
Date 08/03/2019, Ref ESA-EOPSM-HSTR-MRD-3276

TRISHNA design driver scientific objectives

- **Ecosystem stress and water use** (monitoring of energy and water budgets of the continental biosphere, evapotranspiration)
- **Coastal and inland waters** (meso-scale, sub meso-scale dynamics, processes)

TRISHNA other scientific objectives

- **Urban** (climatology and monitoring of fluxes of urban surfaces)
- **Solid Earth** (volcanology, earthquakes, etc...)
- **Cryosphere** (snow-melt run-off, Glacier debris, high-altitude lake dynamics)
- **Atmosphere** (aerosol, water vapour, cloud type)

TRISHNA SMRD 3.0
Date 23/09/2019, Ref TRIS-TS-MI-0028-CNES

TRISHNA

Mission datasheet

- ISRO/CNES cooperation, launch end of 2024, 5-year mission
- Scientific & operational applications
- Focus on **ecosystem stress and water use**
- Global coverage
- Revisit : 3 acquisitions at equator per 8 days period

  761km-8day orbit reducing hot spot constraints in intertropical zone
- 4 TIR bands + 5 VNIR bands + 2 SWIR bands
- ± 34° scan angle, 1030km swath
- Nadir spatial resolution (VIS-NIR-SWIR-TIR):

  57 m for continental and coastal areas, binned at 1 km over open ocean
- Overpass time : 1 PM
- NeDT 0.2K
- Indo-French(*) Joint Science Team, synergies with ECOSTRESS, SBG, LSTM science & application teams (*) with other contributors
- Free and open data policy for worldwide scientific community

Learn more about TRISHNA !
https://labo.obs-mip.fr/multitemp/trishna
https://trishna.cnes.fr/en

Mission requirements: revisit and GSD

Mission specifications: revisit = 3 days, nadir resolution = 57m

Revisit guided by :

- ❑ Cloud frequency / data availability
- ❑ Technical constraints : swath, arrays detector size, view zenith angle
- ❑ Expected products (AET) accuracy

1 day is the goal

3 days is the best possible with single satellite

Puducherry region, India

Spatial resolution guided by :

- ❑ Field size
- ❑ Technical constraints : arrays detector size, swath
- ❑ LST accuracy (*vs* atmospheric turbulence induced fluctuations)

50 - 60 m (nadir)

< 100m (edge)

Brittany region, France
(© Google Earth)

Directional anisotropy in TIR: still a research field

- A uniform viewing configuration on a given site allows minimizing its impact
- With a constant viewing configuration, the angular effect appears as a bias, and not as an error (crucial for temporal analysis)

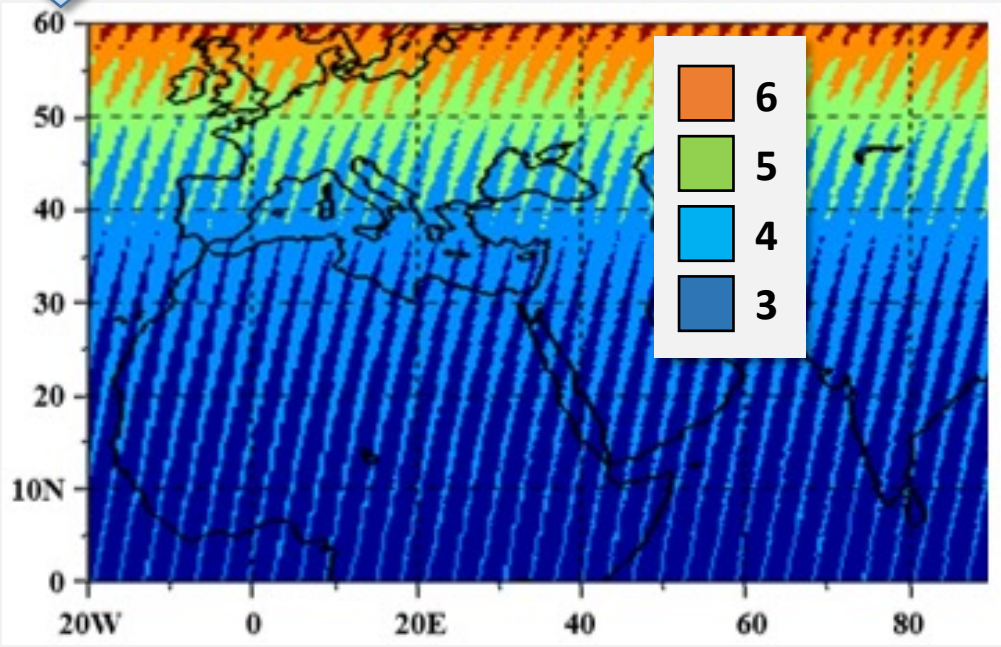
Hot-spot

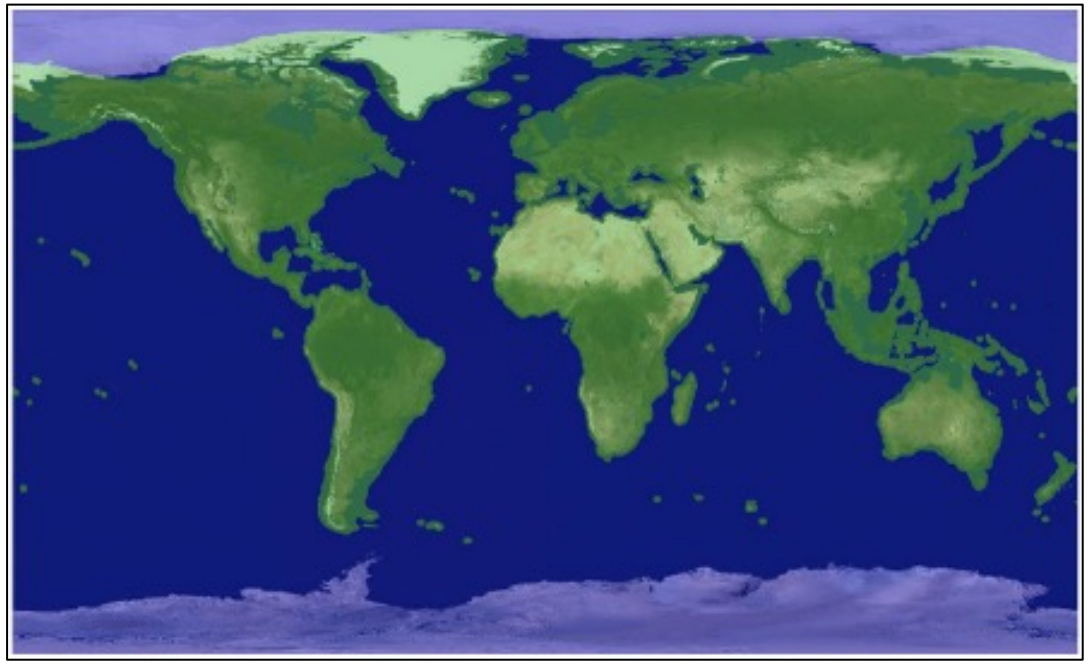
- On a 3-day orbit, intertropical zones measurements can be inside hot-spot conditions, affecting seasonal-long time series
- Different viewing configurations garantee hot-spot free acquisitions, and provides valuable data for studying directional anisotropy

Selected orbit: 761 km altitude / 8 days revisit

- Repeatable geometric conditions every 8 days
- Compatible with global coverage every 3 days with extended swath (+/- 33 deg swath angle)
- Provides 2 hot-spot free acquisitions every 8 days on inter-tropical regions at any period of the year
- Drawback: swath is extended

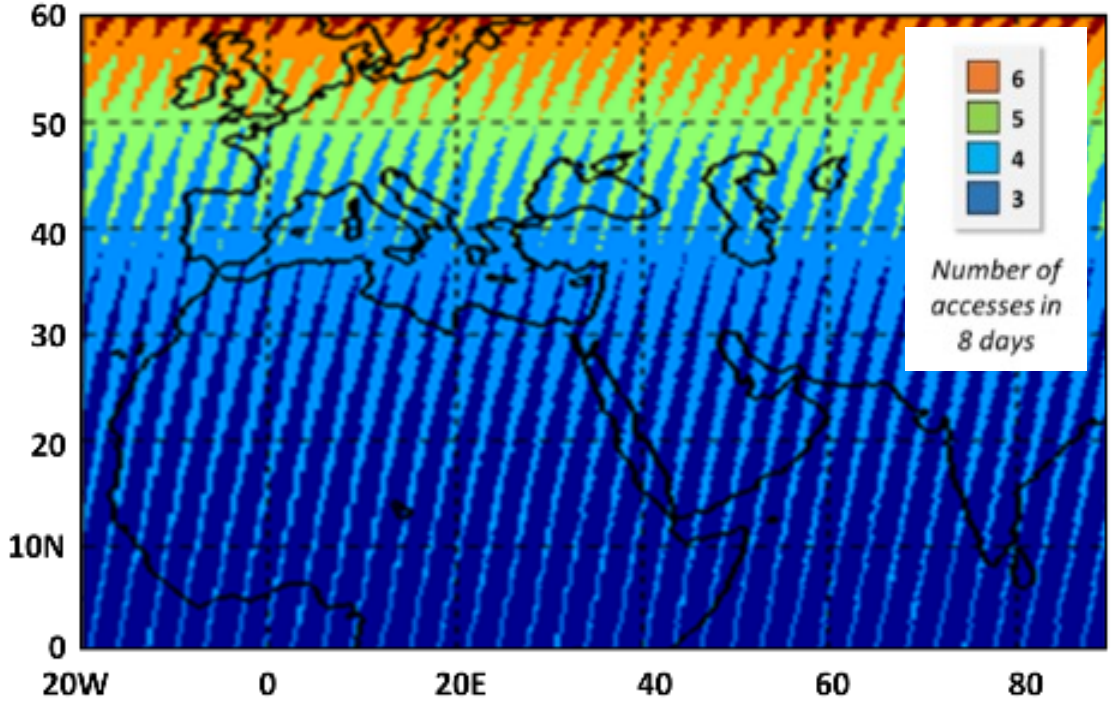
Number of accesses in 8 days (with scan ±34 deg) →





TRISHNA full resolution data coverage (in green)

All continental land surfaces (including inland waters)
All coastal waters up to 100km from the shore



TRISHNA geometric revisit frequency due to the overlap between adjacent orbits

Spectral bands

Band name	Wavelength Center (nm)	FWHM (nm)	Purpose
Blue	485	70	Detection of low clouds
Green	555	70	Coastal, sediments, snow
Red	670	60	Vegetation (LAI, fCOVER, NDVI, …)
NIR	860	40	Vegetation (LAI, fCOVER, NDVI, …)
WV	910	20	Water vapour content estimation
Cirrus	1380	30	Detection of thin cirrus clouds
SWIR	1610	100	AOD, snow/cloud discrimination, vgt stress, burnt areas

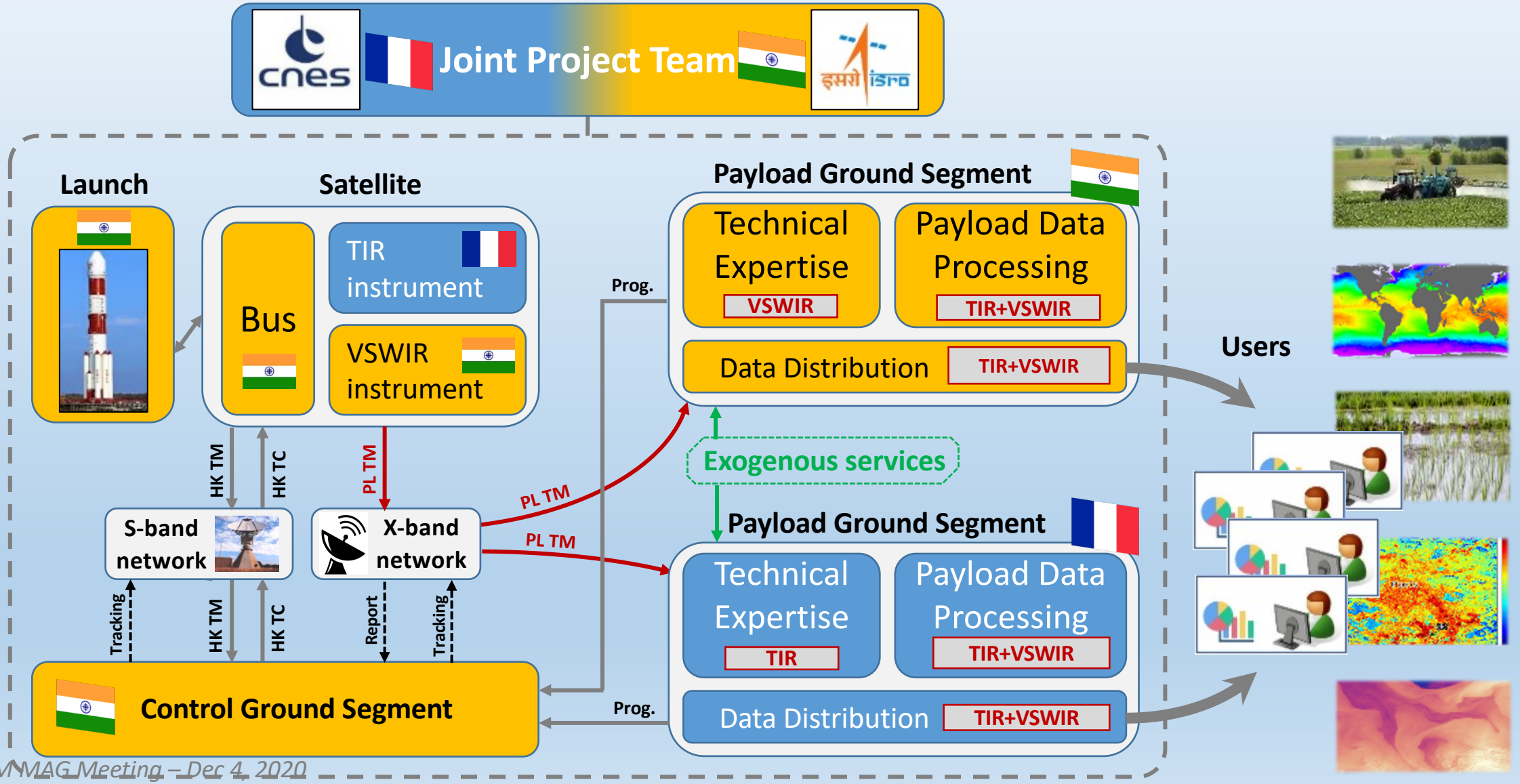
Band name	Wavelength Center (µm)	FWHM (µm)	Purpose
TIR 1	8.65	0.35	Temperature/emissivity separation
TIR 2	9.0	0.35	Temperature/emissivity separation
TIR 3	10.6	0.7	Split-window
TIR 4	11.6	1.0	Split-window

Source: TRISHNA SMRD V3.0

Products definition (work in progress)

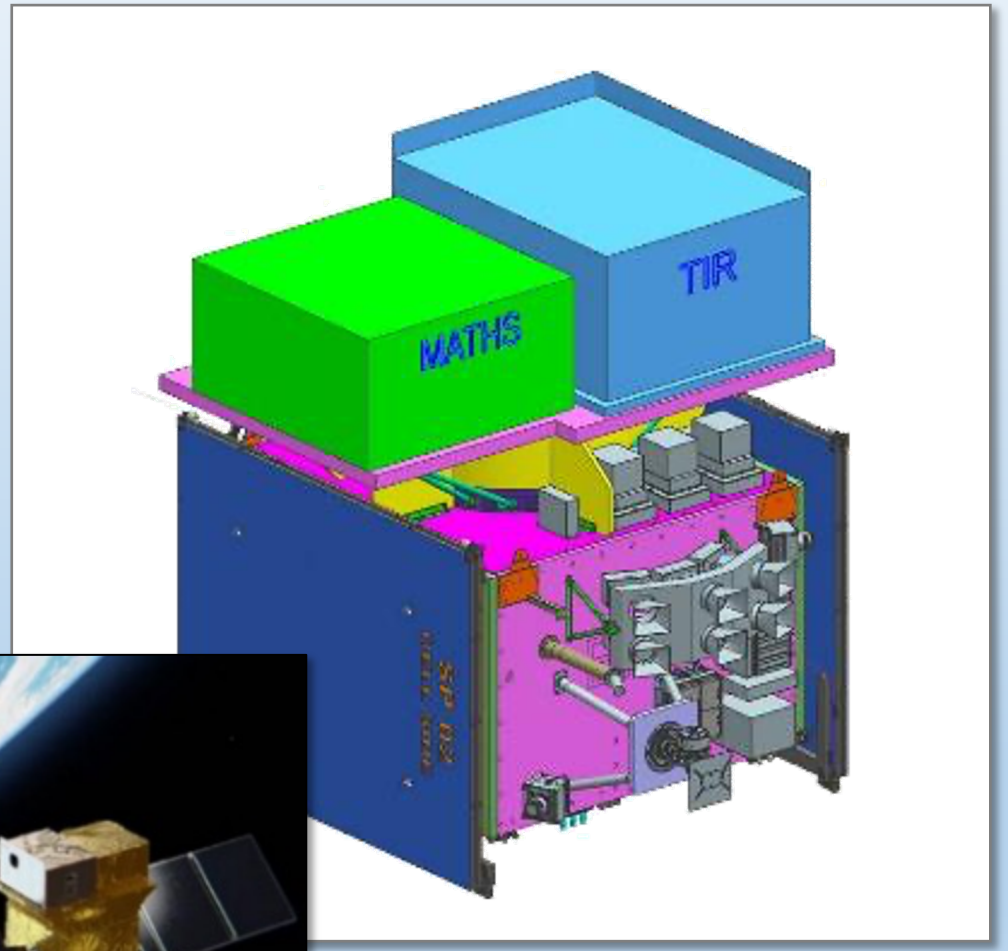
Product level	Visible & Short-wave infrared	Thermal Infrared
0	Raw observation data	Raw observation data
1	Ortho-rectified image Coarse cloud mask Top-of-atm. reflectance	Ortho-rectified image Coarse cloud mask Top-of-atm. Radiance & Brightness temperature
2a	**Radiative variables :** ▪ Scene classification (Cloud, Shadows, Water, Snow, Land) ▪ Atmospheric variables (water vapour, AOT) ▪ Surface reflectance after atmospheric correction, albedo ▪ Surface radiance in TIR after atmopheric correction ▪ Surface temperature, Surface emissivity in TIR	
2b	**Biophysical variables** *(ecosystem stress and water use)*: ▪ leaf area index, fractional vegetation cover, fAPAR ... ▪ net radiation, evapo-transpiration, water stress index ...	
3a	Periodic Syntheses (decadal, monthly) of radiative variables (see Level 2A)	
3b	Periodic Syntheses (decadal, monthly) of biophysical variables (see Level 2B) ▪ land cover ▪ mask of irrigated crops	

TRISHNA Project Organization



TRISHNA

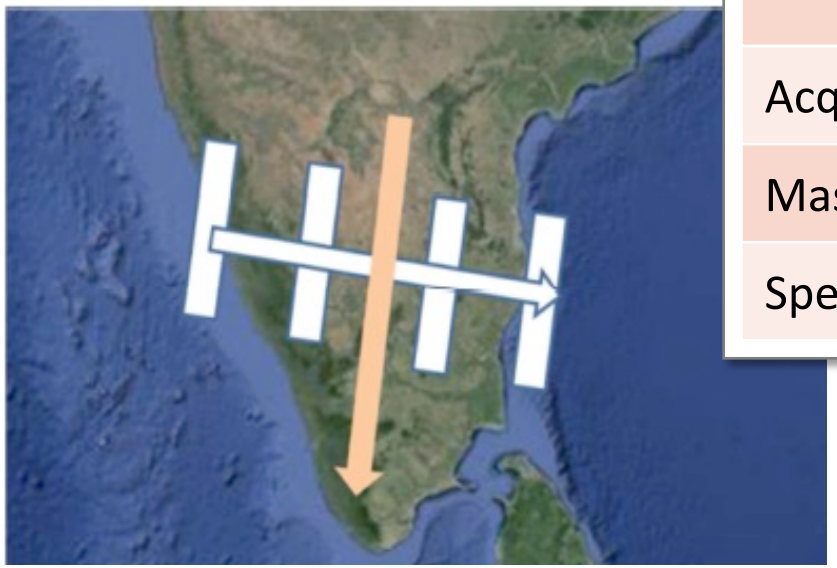
TRISHNA Bus



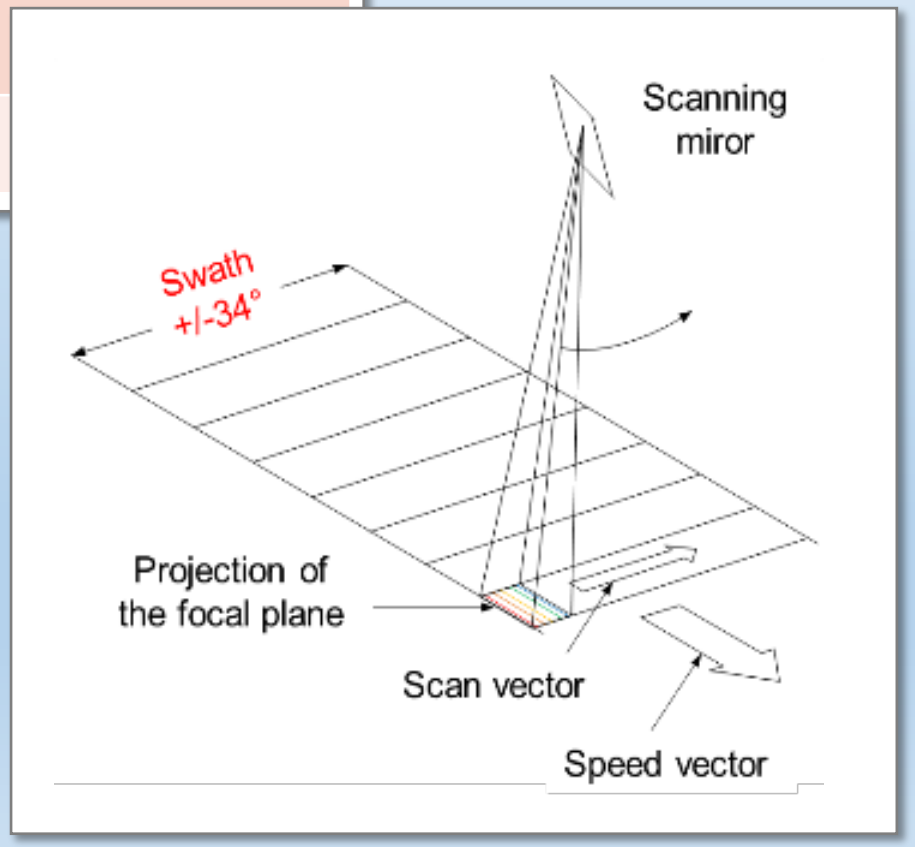
Developed by	**ISRO**
Platform mass	770 kg
Payload capacity	450 kg
Power generation	2 kW
Pointing Accuracy	+/- 0.05 deg
Drift rate	5.10^{-4} deg/s
TM/TC	S-band, 4kbps
X-band	640 Mbps
Mass Memory	1.4 Tb

TRISHNA Thermal Infrared Instrument: acquisition mode

Developed by	**AIRBUS DEFENCE AND SPACE**
Acquisition	Across track scanner
Mass	195 kg
Spectral bands	4 TIR



600 pixels x 15845 scan samples
= 1 strip



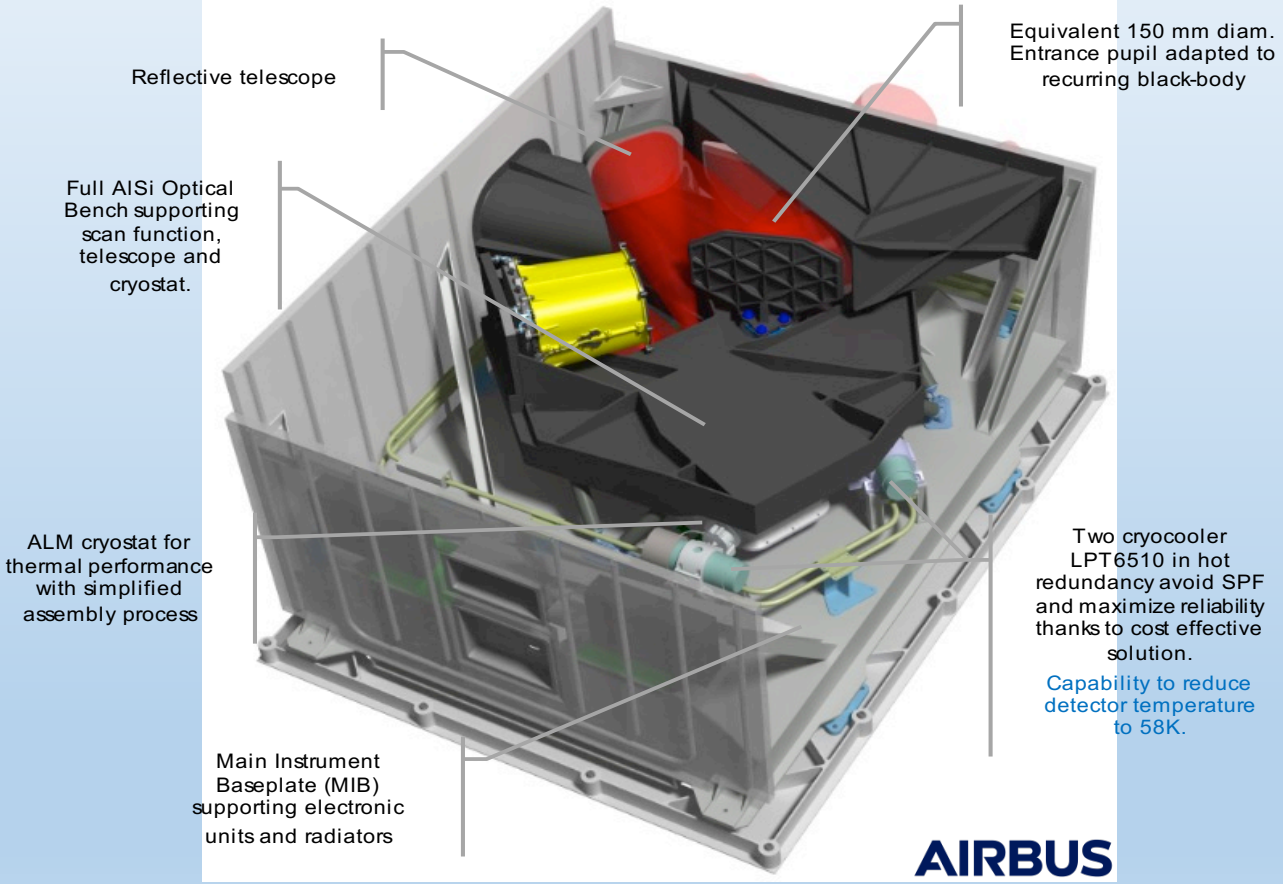
TRISHNA Thermal Infrared Instrument: main requirements

Swath	**Cross-track view angle ± 34 °**
Spatial sampling	**57 m nadir over land and coastal areas** **1000 m binning over oceans**
Pointing requirements	Absolute pointing accuracy +/-0.1° Pointing stability (1 year) +/-10 pixels Pointing stability (short term) +/-0.6 pixel Sampling regularity 5% (over 100 pixels) Inter band registration stability (1 year) +/-0.5 pixel
Lifetime	5 years
Interfaces	**Mass 195 kg** **Power 265 W**

TIR bands	TIR 1	TIR 2	TIR 3	TIR 4
Spectral requirements				
λ equivalent	**8.65 µm**	**9.0 µm**	**10.6 µm**	**11.6 µm**
FWHM	0.35 µm	0.35 µm	0.7 µm	1.0 µm
In field spectral uniformity	0.2%			
Radiometric requirements				
Total noise @57m @300K	**0.25K**	**0.25K**	**0.2K**	**0.2K**
Total noise @1000m @ 300K	0.1K			
MTF @Nyquist	[0.05 – 0.15]			
Calibration @300K **Absolute** Inter band Multi temporal	**0.5K** 0.3K 0.3K			

TRISHNA Thermal Infrared Instrument: key features

- Scan subsystem based on recurring elements from IASI-NG scan mechanism and associated electronics
- Instrument entrance pupil equivalent diameter 150 mm
- Recurring blackbody from IASI-NG
- Full AlSi TMA telescope and optical bench
- Telecentric optical design
- Focal plane cooled down to 60K includes a detector from LYNRED and 4 spectral filters
- Cryostat in Additive Layer Manufacturing technology
- LPT6510 cryocoolers in hot redundancy



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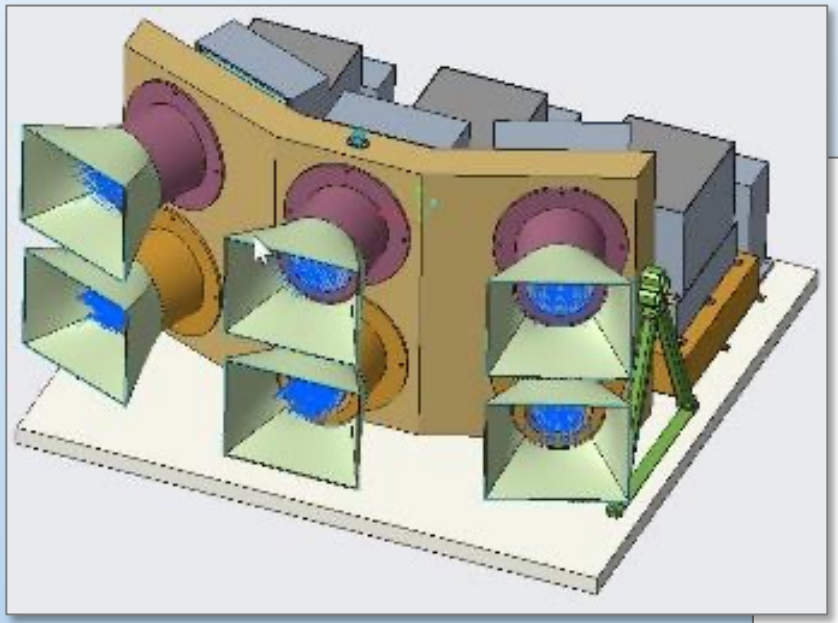
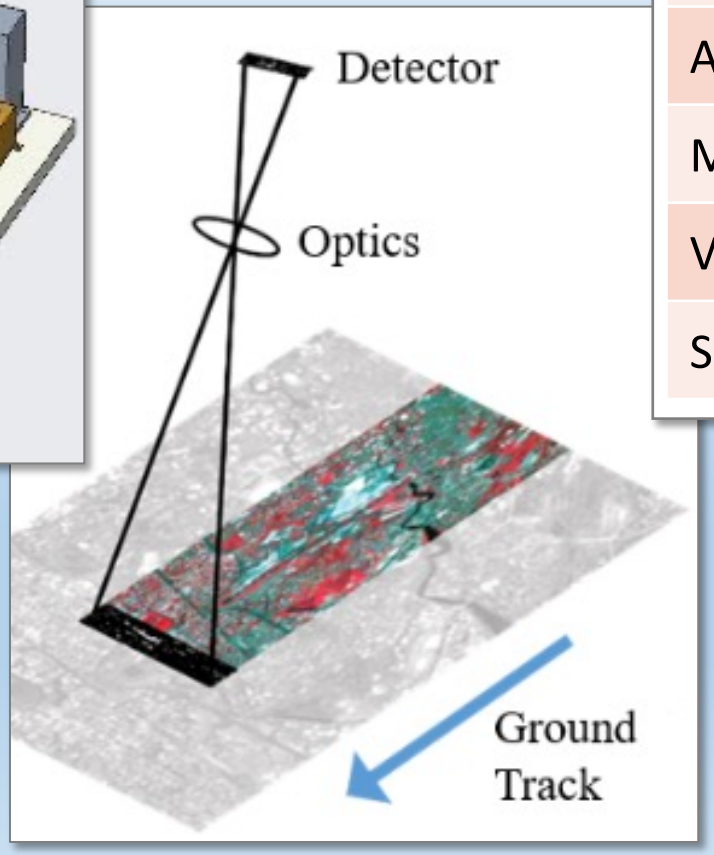
TRISHNA VIS – NIR – SWIR instrument





Developed by	**ISRO**
Optical Heads	6
Acquisition	Pushbroom
Mass	90 kg
VIS & NIR bands	5
SWIR bands	2

Why ?

- Related scientific communities involved, common societal challenges. TRISHNA's role: contribute to the preparation of LSTM: the operational mission
- « Operational » complement:
  - ✓ Temporal revisit is a key factor of EvapoTranspiration retrieval performance (cf study by Albert Olioso, INRAE, presented at ESA Earth Observation for Water Cycle Science 2020 Worskhop)
  - ✓ The goal requirement is daily revisit, which is not fulfilled by any mission alone
  - ✓ We have to fill the gaps within the time series of LST from remote sensing data

How ?

- Essential consistency in the design of the missions by science teams coordination (mostly at MAG level)
- Share the work in the CAL/VAL process (protocols, sites, data).
- In-flight cross-calibration:
  - ✓ vicarious calibration sites and strategy
  - ✓ dealing with directional anisotropy of the TIR signal is crucial (explored by TRISHNA)
- Data policy / processing / distribution

LSTM / TRISHNA

	LSTM	TRISHNA
Number of satellites	2	1
Combined revisit	2 days (same obs. angles)	2 to 3 days (different obs. angles)
Altitude	649 km	761 km
Orbit cycle	4 days for each sat.	8 days
GSD (nadir/edge of scan)	37 m / 50 m	57 m / 90 m
FOV	+/- 28 deg	+/- 34 deg
Swath	700 km	1000 km
Coverage	Land & coastal	Land & coastal
Day/Night	Day + Night	Day + Night
LTDN	1 PM	1 PM
LWIR bands (8-12µm)	5	4
VNIR / SWIR / MWIR	4 / 2 / 0	5 / 2 / 0
NeDT	<0.15 K	0.2 K
Data latency	6-12h	12h (demo)