METimage Instrument – Design and Performance of the VII mission on MetOp-SG

Living Planet Symposium 2022
25 May 2022, Bonn

Isabel Zerfowski, METimage Project Manager, DLR
Frank Schmülling, METimage System Engineer, DLR
Dirk Ballhause, METimage Project Manager, Airbus
Oswald Wallner, METimage System Engineer, Airbus

METimage

- METimage is the VII mission on MetOp-SG A satellite
- Key instrument and Germany´s contribution to the EPS-SG programme
- Co-funded by the German Ministry for Digital and Transport and EUMETSAT
  - 3 Instruments for mission lifetime of 21 y

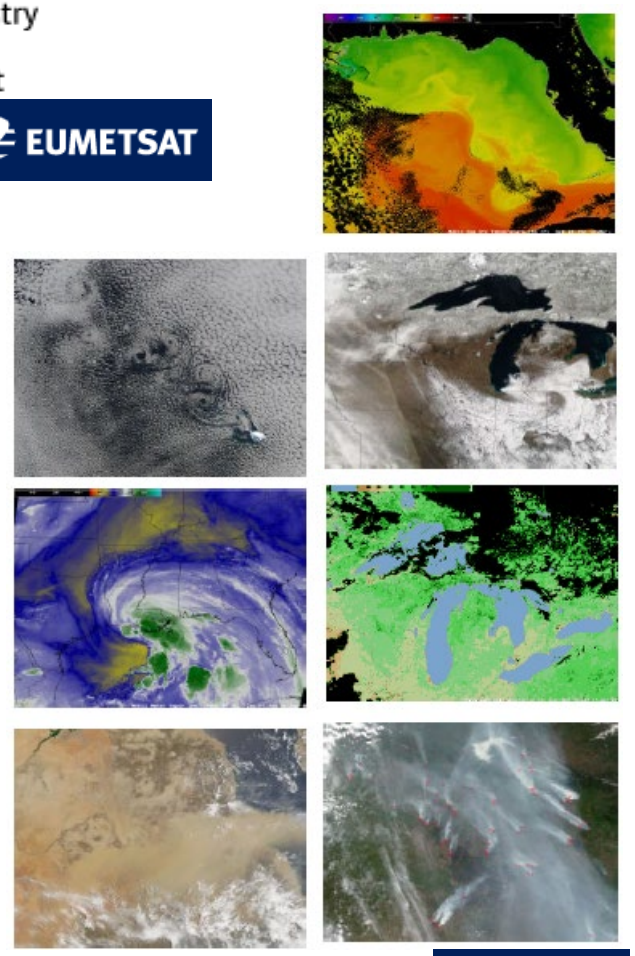
Federal Ministry for Digital and Transport

EUMETSAT

- DLR Space Agency is the contracting entity
- Prime contractor is Airbus Defence and Space, Germany
  - ~30 subcontractors and major suppliers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

AIRBUS

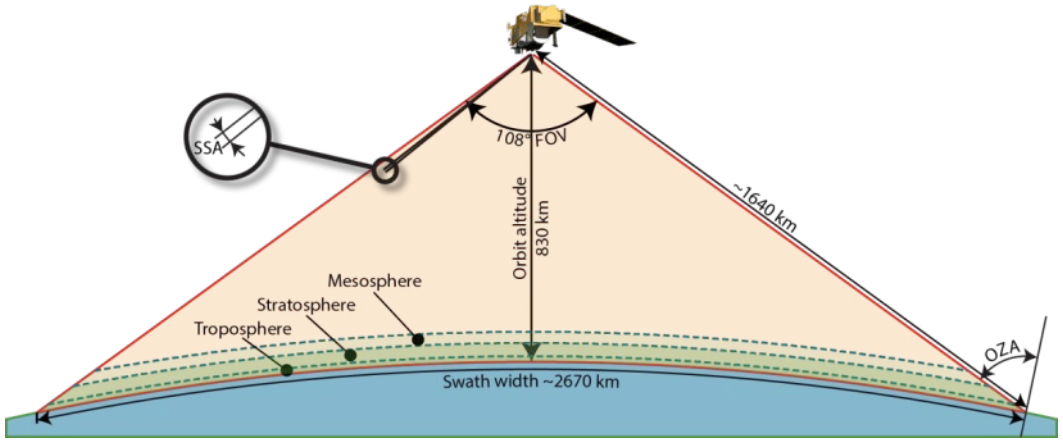


- METimage will provide high quality imagery data for numerical weather prediction (NWP), nowcasting (NWC) and climate
  - Clouds, Water Vapour and Aerosols
  - Land & Sea Surface Temperature
  - Cryosphere
  - Vegetation
  - Fire

DLR

EUMETSAT

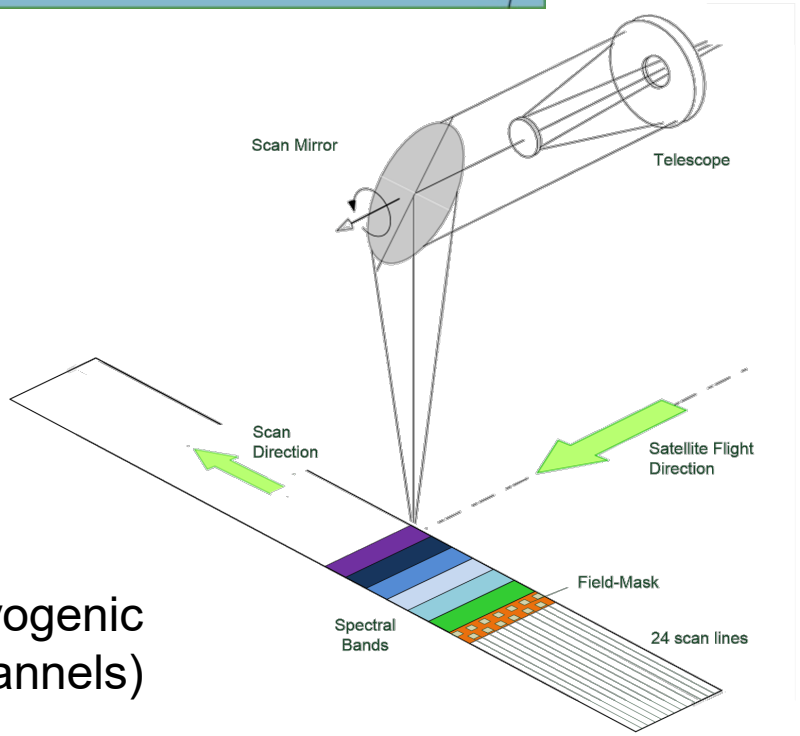
Design Concept



- Passive multi-spectral imaging radiometer
  - 20 spectral channels: 443 nm – 13.345 µm
  - 500 m GSD at Nadir
  - Full Earth coverage within 1 day

- Whiskbroom scanner
  - ±53° Earth view
  - Continuous scanning: 1.7 sec, acceleration/decelaration
  - In-beam scanner: scan mirror and image derotator
  - Regular calibration views

- 3 focal planes
  - VNIR: solar bands up to ~1 µm, ambient
  - 2 IR detectors, SMWIR up to 4 µm, thermal bands up to 13 µm, cryogenic
  - 24 pixels in flight direction, 28 channels in scan direction (8 TDI channels)



Images credit: AIRBUS

Overall Design

- Nadir panel units
  - Optical head (MOH)
  - External electric assembly (EEA)
  - Solar calibration device (SCAD) baffle
- Instrument harness
- PEB units
  - Central electronics (MCE)
  - Cryocooler Electronics (CCE)
  - Cross strap box (XSB)

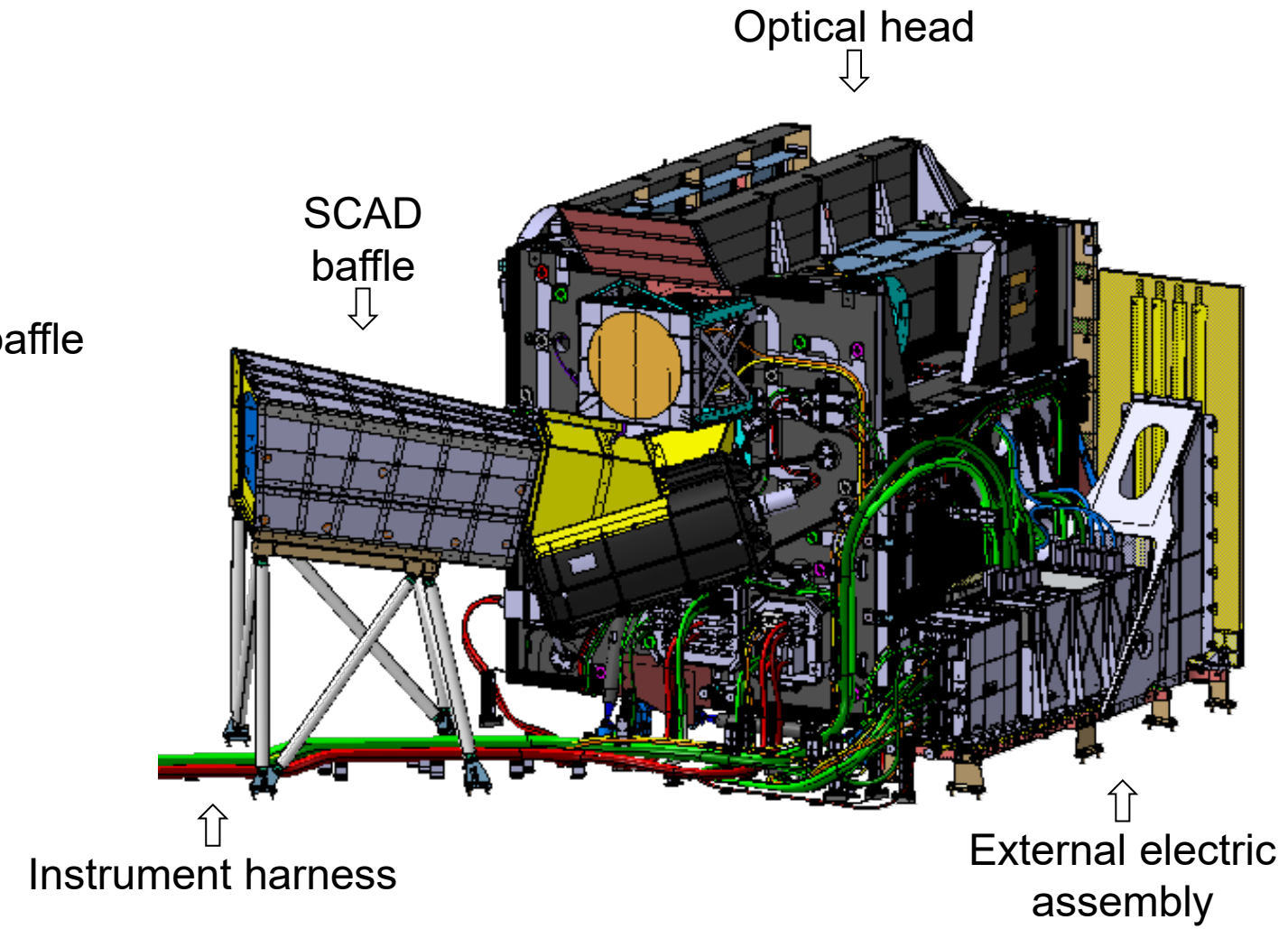
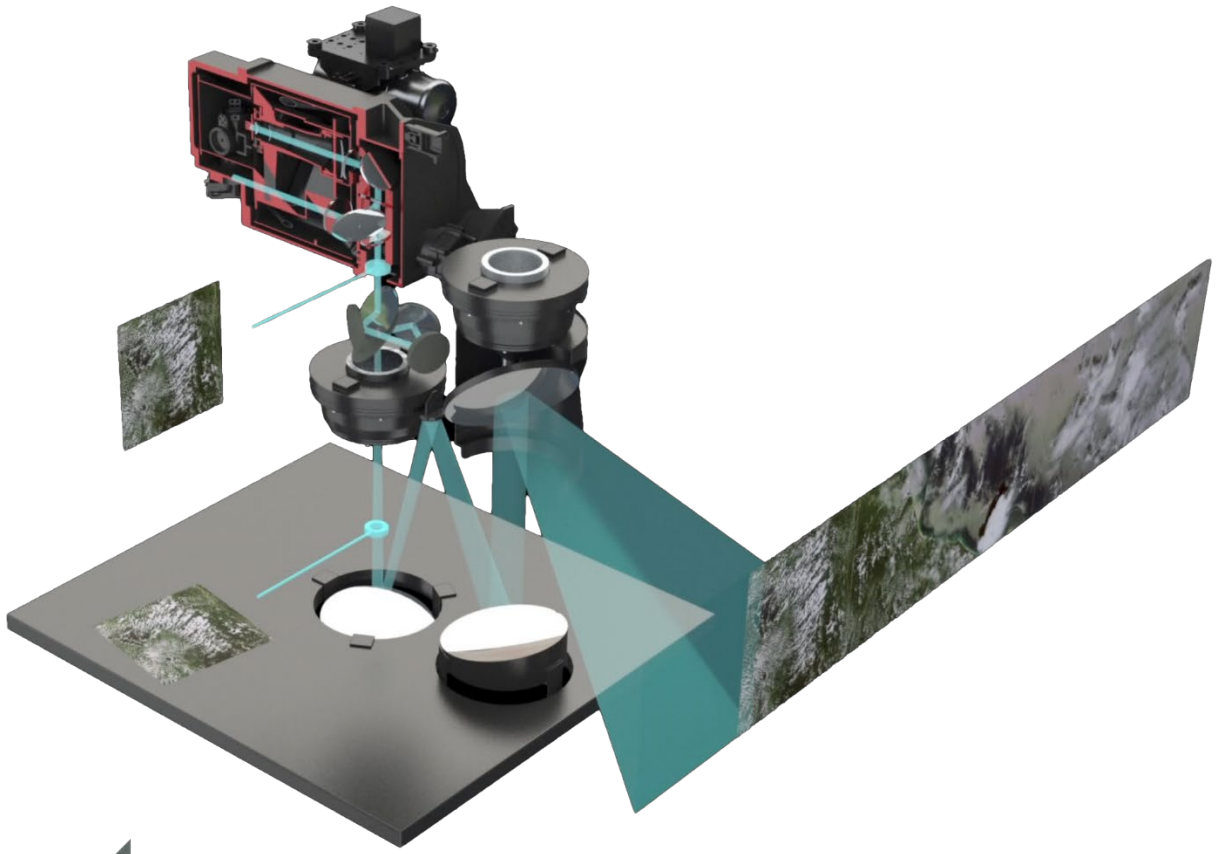
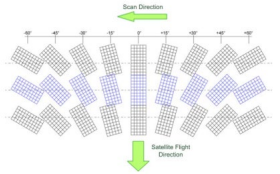


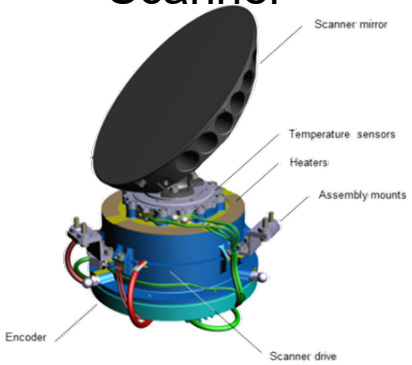
Image credit: AIRBUS

Optical Subsystems Design

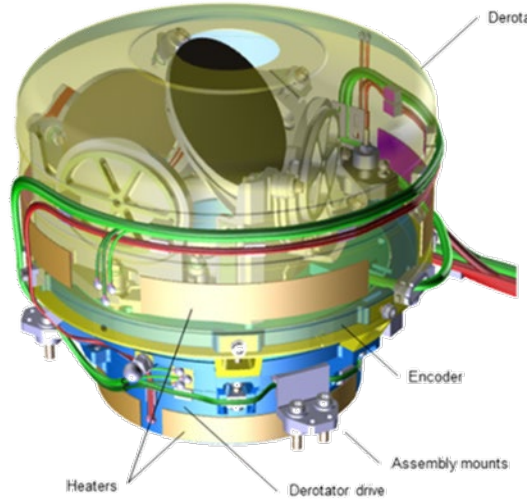




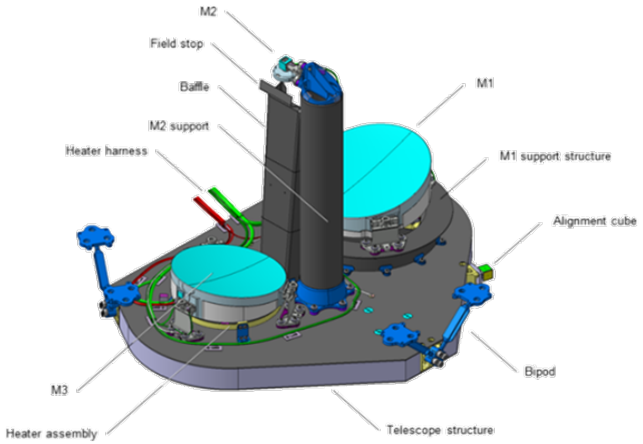
Scanner

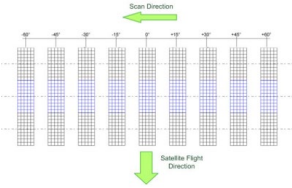


Derotator



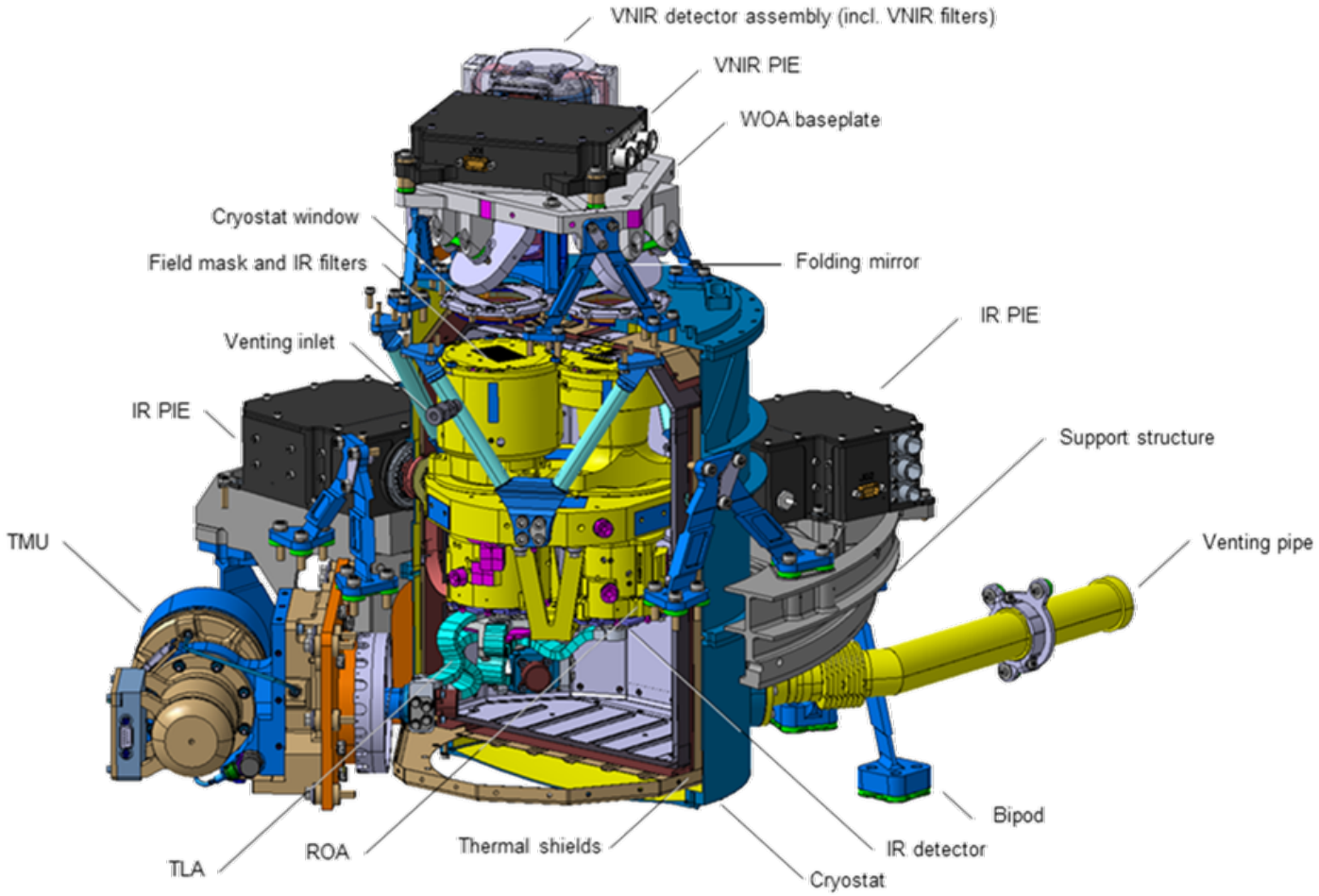
Telescope



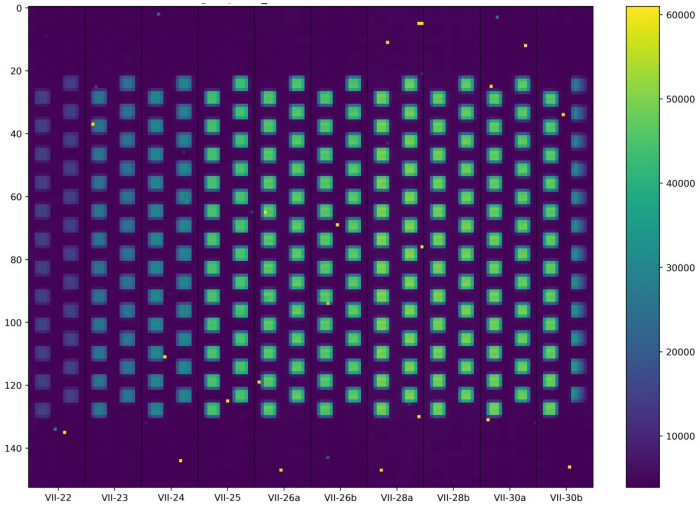


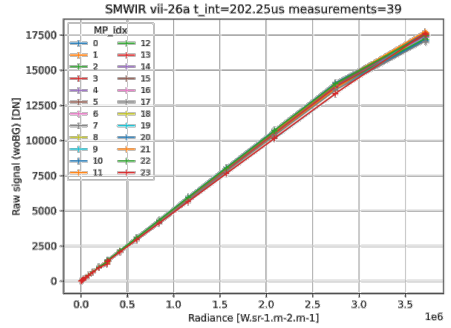
Images credit: AIRBUS

The cryogenic subsystem



SMWIR PFM detector flat field illumination





Images credit: AIRBUS

Instrument Performance – Key Requirements & Drivers

- Spatial co-registration (L0):
  → alignment & stability

Co-Registration Margins VISNIR - VISNIR							
Channel	VII-4	VII-8	VII-12	VII-15	VII-16	VII-17	VII-20
VII-4		86%	81%	74%	72%	79%	70%
VII-8			86%	79%	76%	83%	73%
VII-12				84%	80%	87%	75%
VII-15					86%	86%	80%
VII-16						79%	85%
VII-17							78%
VII-20							

Co-Registration Margins VISNIR - SMWIR							
Channel	VII-22	VII-23	VII-24	VII-25	VII-26	VII-28	VII-30
VII-4	70%	58%	53%	47%	44%	34%	26%
VII-8	72%	58%	54%	51%	48%	38%	30%
VII-12	73%	58%	54%	53%	53%	43%	35%
VII-15	69%	54%	51%	51%	56%	50%	42%
VII-16	64%	47%	43%	43%	50%	51%	43%
VII-17	72%	57%	53%	52%	55%	46%	38%
VII-20	58%	40%	36%	35%	41%	47%	43%

Co-Registration Margins VISNIR - VLWIR						
Channel	VII-33	VII-34	VII-35	VII-37	VII-39	VII-40
VII-4	56%	58%	58%	54%	47%	26%
VII-8	60%	61%	61%	59%	51%	30%
VII-12	63%	63%	63%	62%	56%	33%
VII-15	61%	61%	61%	61%	59%	39%
VII-16	55%	55%	55%	55%	54%	41%
VII-17	61%	61%	61%	61%	56%	35%
VII-20	47%	46%	46%	46%	45%	41%

Co-Registration Margins SMWIR - SMWIR							
Channel	VII-22	VII-23	VII-24	VII-25	VII-26	VII-28	VII-30
VII-22		63%	54%	49%	47%	39%	32%
VII-23			75%	69%	65%	55%	48%
VII-24				77%	73%	64%	56%
VII-25					82%	72%	64%
VII-26						76%	68%
VII-28							78%
VII-30							

Co-Registration Margins SMWIR - VLWIR						
Channel	VII-33	VII-34	VII-35	VII-37	VII-39	VII-40
VII-22	54%	52%	50%	47%	41%	22%
VII-23	61%	63%	62%	59%	52%	32%
VII-24	63%	66%	66%	63%	58%	37%
VII-25	66%	68%	69%	68%	63%	44%
VII-26	61%	62%	63%	63%	63%	45%
VII-28	55%	54%	55%	56%	58%	53%
VII-30	48%	48%	48%	50%	52%	55%

Co-Registration MarginsVLWIR - VLWIR						
Channel	VII-33	VII-34	VII-35	VII-37	VII-39	VII-40
VII-33		83%	80%	77%	70%	45%
VII-34			83%	80%	70%	44%
VII-35				82%	73%	46%
VII-37					78%	51%
VII-39						61%
VII-40						

- Radiometric noise:
  → coatings, IR detector temp.

VISNIR SNR	VII-4	VII-8	VII-12	VII-15	VII-16	VII-17	VII-20
@E_min	-	-	-	-	-	-	-
@E_ref	221	215	66	400	400	60	250
@E_max	221	215	66	400	400	60	250
@E_min	-	-	-	-	-	-	-
@E_ref	267	256	102	647	532	84	443
@E_max	3220	4385	4447	3903	3768	2780	2827
@E_min	-	-	-	-	-	-	-
@E_ref	21%	19%	55%	62%	33%	40%	77%
@E_max	1357%	1939%	6637%	876%	842%	4533%	1031%

SMWIR SNR	VII-22	VII-23	VII-24	VII-25	VII-26	VII-28	VII-30
@E_min	-	-	-	-	0.181	0.18	0.218
@E_ref	75	300	300	110	467	335	353
@E_max	75	300	300	110	1042	713	718
@E_min	-	-	-	-	0.257	0.274	0.351
@E_ref	131	270	369	106	551	433	457
@E_max	2135	2330	2022	2018	1070	806	843
@E_min	-	-	-	-	30%	34%	38%
@E_ref	75%	-10%	23%	-4%	15%	23%	23%
@E_max	2747%	677%	574%	1734%	3%	12%	15%

VLWIR SNR	VII-33	VII-34	VII-35	VII-37	VII-39	VII-40
@E_min	10	11	32	80	121	38
@E_ref	123	159	1065	1322	1476	206
@E_max	368	388	1514	1757	1904	319
@E_min	27	47	98	181	223	51
@E_ref	333	678	2839	2731	2570	276
@E_max	965	1568	3857	3534	3260	426
@E_min	63%	78%	67%	56%	46%	25%
@E_ref	63%	77%	62%	52%	43%	25%
@E_max	62%	75%	61%	50%	42%	25%

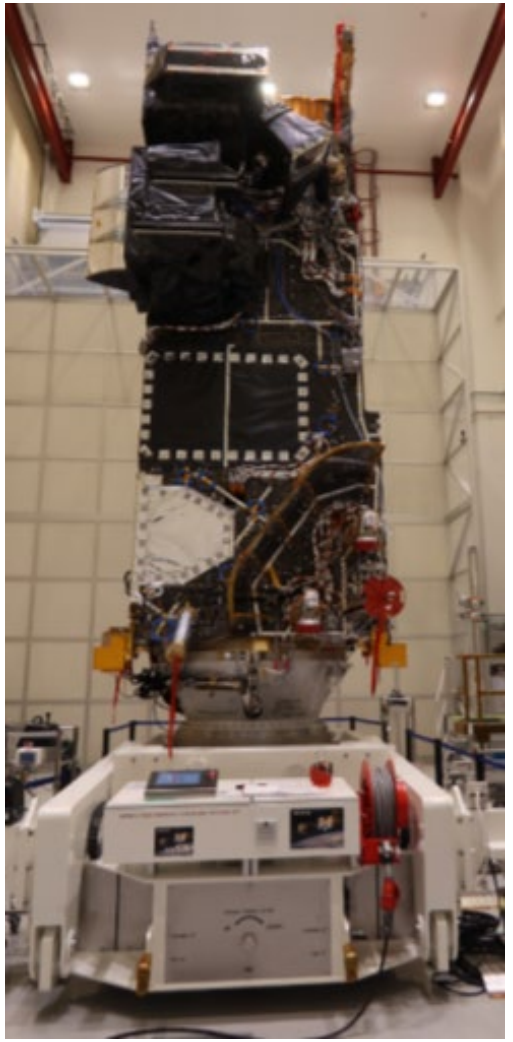
- Radiometric accuracy:
  → straylight, detector non-linearity

VII26	VII28	VII30	VII33	VII34	VII35	VII37	VII39	VII40
0.045	0.053	0.052	0.080	0.052	0.072	0.063	0.061	0.084

Row	VII28	VII30	VII33	VII34	VII35	VII37	VII39	VII40
VII26	0.031	0.032	0.076	0.062	0.071	0.067	0.067	0.080
VII28	0.000	0.032	0.076	0.066	0.072	0.067	0.067	0.081
VII30	0.000	0.000	0.073	0.062	0.069	0.065	0.066	0.081
VII33	0.000	0.000	0.000	0.053	0.066	0.073	0.080	0.096
VII34	0.000	0.000	0.000	0.000	0.052	0.059	0.065	0.084
VII35	0.000	0.000	0.000	0.000	0.000	0.058	0.064	0.081
VII37	0.000	0.000	0.000	0.000	0.000	0.000	0.046	0.065
VII39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.057

Achievements – Instrument fE-EM

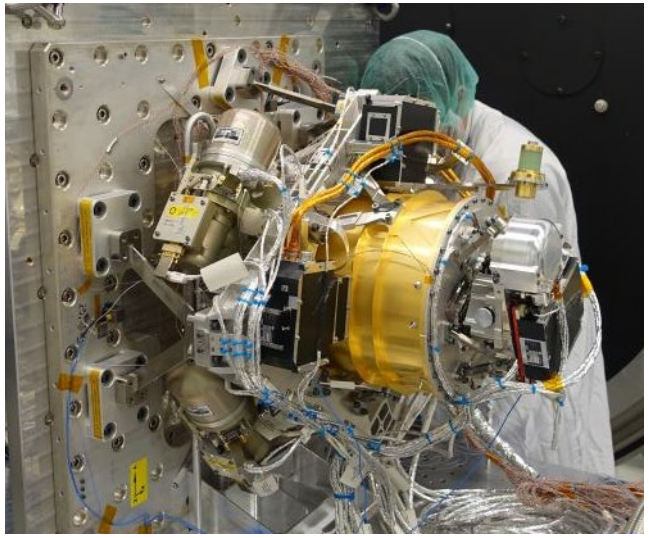
- Instrument fE-EM IVHRR (=DRB) successful in Aug 2021
- Instrument fE-EM delivered to Satellite Prime
  - Incoming bench test
  - Mechanical integration onto Satellite-A
  - Electrical integration and FFT
  - Soft cover installation

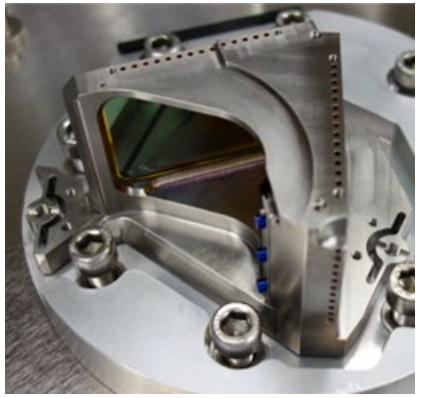


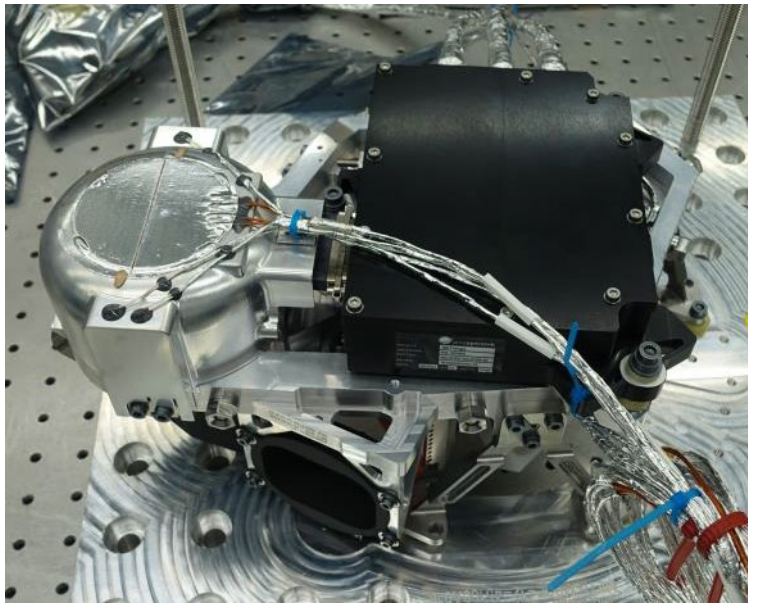
images courtesy of Airbus Defence & Space SAS

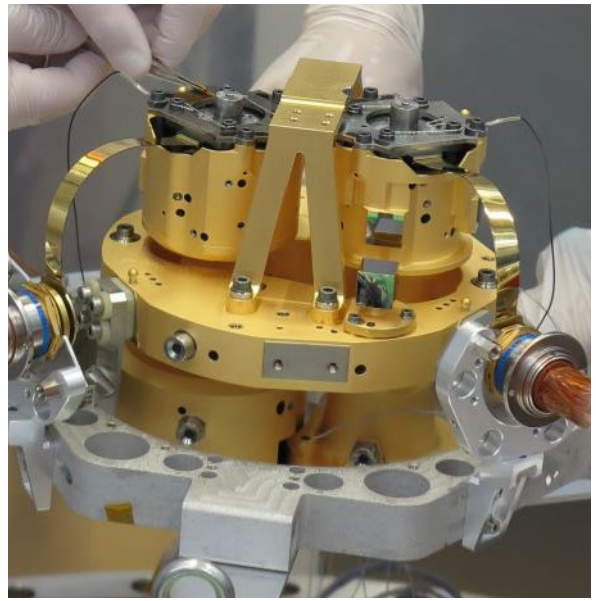
Achievements – Cryogenic Subsystem

- STM: successful mechanical and thermal qualification
  - demonstration of cryogenic performance
- PFM integration ongoing
  - Cryogenic imaging assembly (IR detectors, relay optics, filters, field masks) integrated, aligned and tested successfully with FEE
  - Warm optical assembly (beam splitters, VNIR detector, filters, fold mirrors) integrated and aligned; VNIR detector successfully tested with FEE





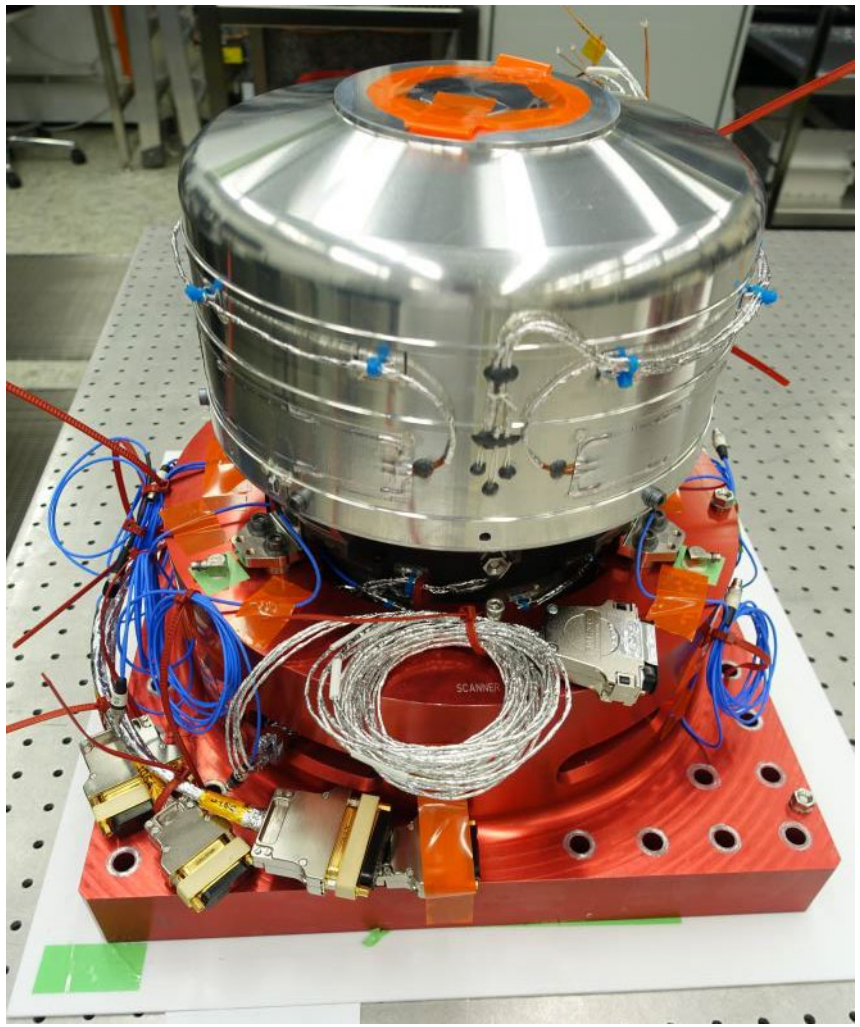




Images credit: AIRBUS

Achievements – Instrument PFM

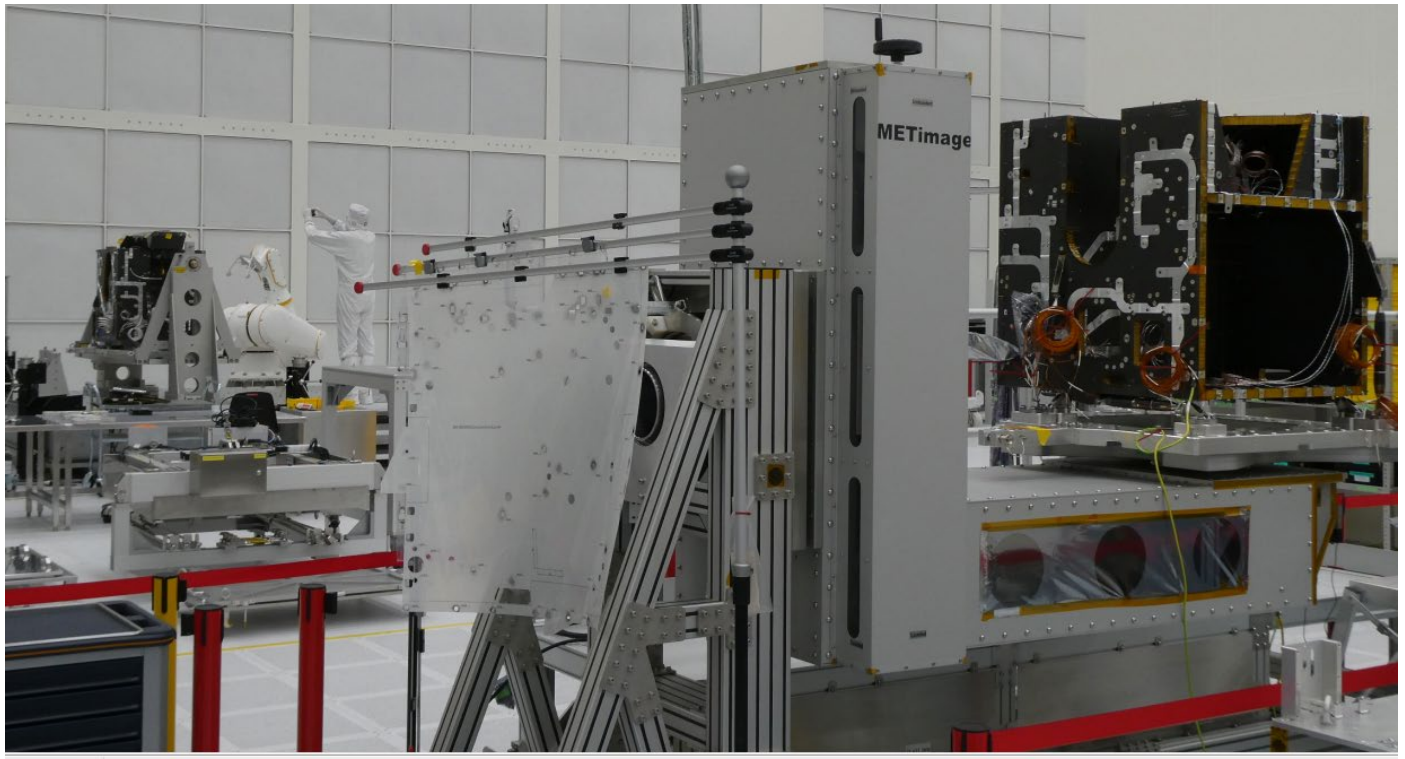
- Derotator assembly FM:
  - Derotator optics FM delivered
  - Assembly successfully integrated, aligned and tested
  - Ready for integration into instrument

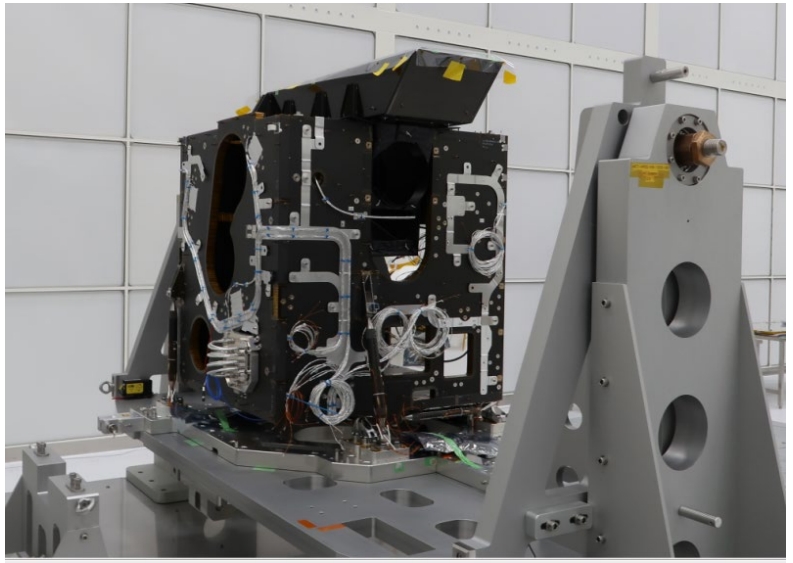


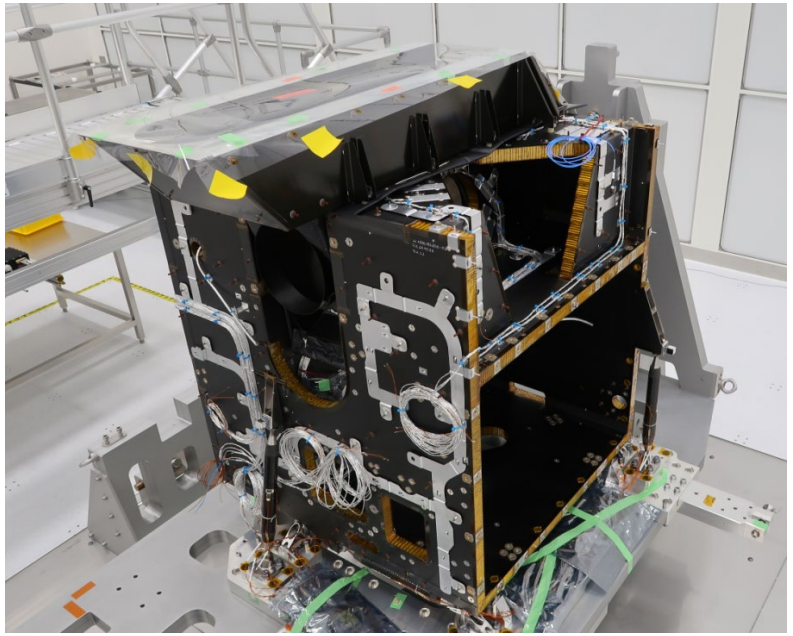
Images credit: AIRBUS

Achievements – Instrument PFM

- Instrument PFM integration in progress
  - Optical head structure, radiator, baffles integrated
  - Electronic units delivered: MCE, CCE, XSB, TAEU, FEE





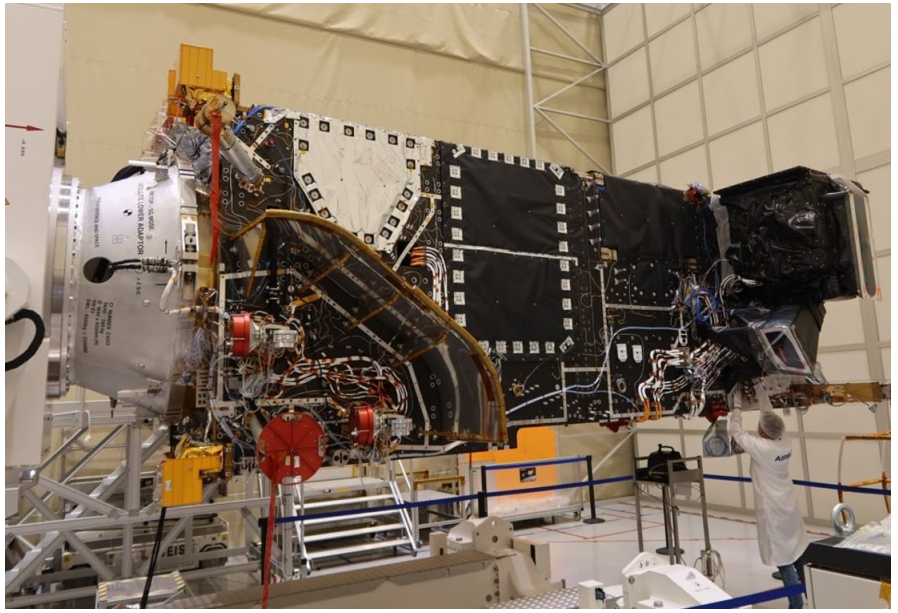


Images credit: AIRBUS

METimage Outlook

- METimage fE-EM integrated on MetOp-SG A and ready to support the satellite level testing

- METimage PFM
  - Continuation of the instrument PFM integration
  - CGSS integration and test program
  - Functional test program
  - FM2 Assembly & Integration started
- Environmental testing and calibration and characterisation program
- DRB and hand-over to satellite prime early 2024



images courtesy of Airbus Defence & Space SAS

Thank you for your attention!

Acknowledgements:
The METimage project is co-funded by the Federal Ministry of Digital and Transport and EUMETSAT under grant number 50EW1521.
The photos and pictures used in this presentation are courtesy of Airbus Defence and Space unless indicated otherwise.