Status of MET*image* studies

Isabel Zerfowski, Frank Schmülling, Christian Brüns

3rd Post-EPS User Workshop

Darmstadt, 29 -30 September 2011

MET*image* - programmatics

- MET*image* is designed to be the Visual/Infrared Imager on the satellites of the EUMETSAT follow-on Polar System (EPS-SG / Post-EPS)
- MET*image* is developed by Jena-Optronik GmbH
- Germany intents to provide the first flight unit of MET*image* as in-kind contribution to the EPS-SG Programme
- A concept paper on the cooperation has been agreed between EUMETSAT and German Space Agency

MET*image* – mission objectives

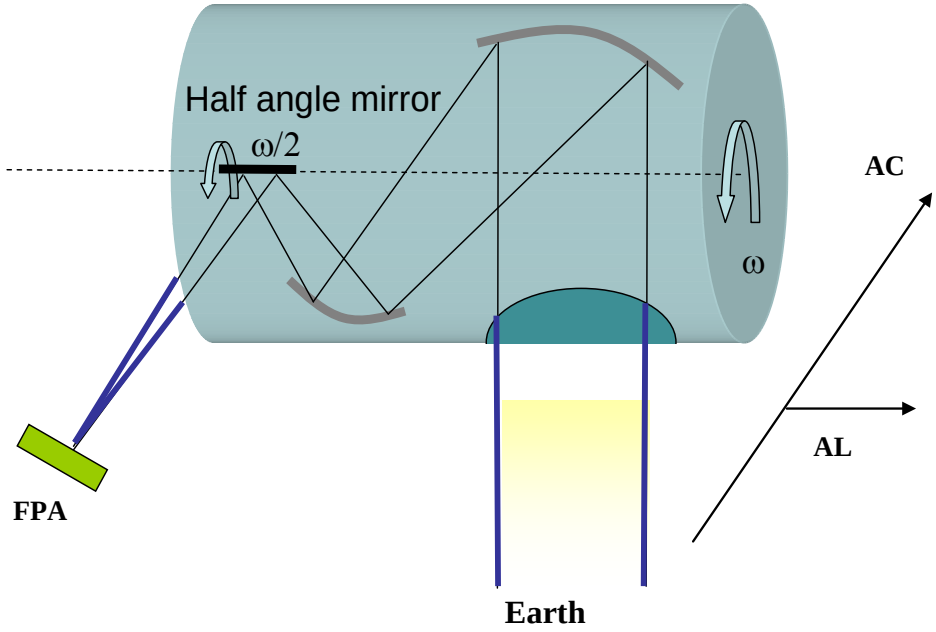
- MET*image* is a cross-purpose medium resolution, multi-spectral optical imager
  - Approx. 20 channels on two focal planes
  - Resolution 500 m (250 m @ 670 and 865 nm)
  - scan range 110° (≈ 2800 km swath)
- Products to be derived from the VII mission are:
  - Cloud observations including microphysical analysis
  - Water-vapour imagery
  - Aerosol observations
  - Polar Atmospheric Motion Vectors (AMVs)
  - Earth surface albedo
  - Vegetation
  - Cryosphere (snow observations, sea and land ice imagery)
  - Fire observations
  - Surface temperature (land and sea)

METimage – baseline channels

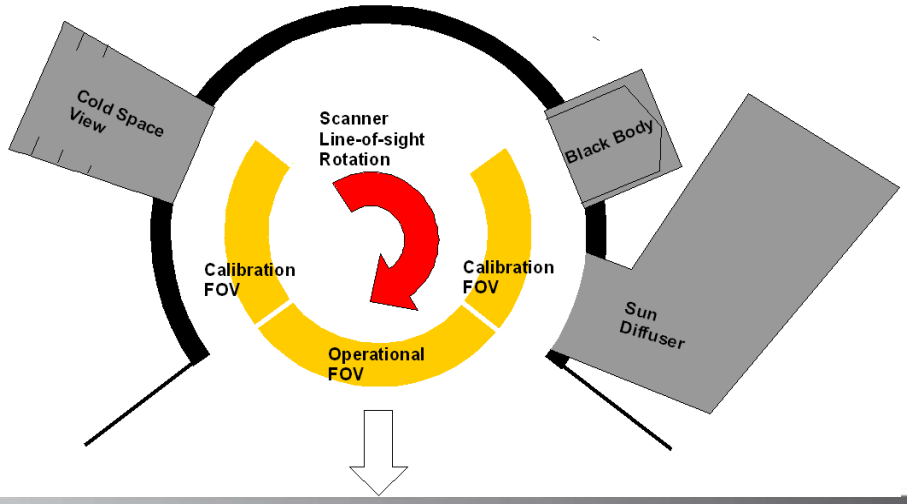
λ (nm)	Δλ (nm)	Cloud	Cloud top height	Water vapour	Aerosol	Cirrus	Vegeta-tion	Surface temp	Primary observations
443	**30**	**X**			**X**	**X**	**X**		**Clouds and aerosol**
555	**20**	**X**			**X**	**X**	**X**		**Clouds, aerosol and vegetation**
670	**20**	**X**			**X**	**X**	**X**		**Clouds, aerosol and vegetation**
763	10		X		X				Cloud and aerosol height assignment
763	40		X		X				Cloud and aerosol height assignment
865	**20**	**X**		**X**	**X**	**X**	**X**		**Clouds, aerosol and vegetation**
940	**50**	**X**		**X**	**X**	**X**	**X**		**Water vapour**
1,240	20	X			X	X	X		Clouds, aerosol and vegetation
1,365	**40**	**X**		**X**	**X**	**X**	**X**		**High level clouds and aerosol and water vapour imagery**
1,630	**20**	**X**			**X**	**X**	**X**		**Cloud phase and surface properties**
2,250	**50**	**X**			**X**	**X**	**X**		**Cloud microphysical analysis**
3,740	**180**	**X**			**X**	**X**		**X**	**SST**
3,959	**40**							**X**	**SST and fire**
4,040	60							X	SST
6,725	**370**	**X**		**X**					**Water vapour imagery and polar winds**
7,325	**290**	**X**		**X**					**Water vapour imagery and polar winds**
8,540	**290**	**X**		**X**	**X**	**X**			**Cirrus clouds**
10,790	**500**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**Split window for clouds and surface parameters**
12,020	**500**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**Split window for clouds and surface parameters**
13,345	**310**	**X**	**X**			**X**			**Cloud top height.**

- Channel selection nearly finalised
- Channel ordering on focal plane wrt co-registration requirements ongoing

METimage – rotating telescope

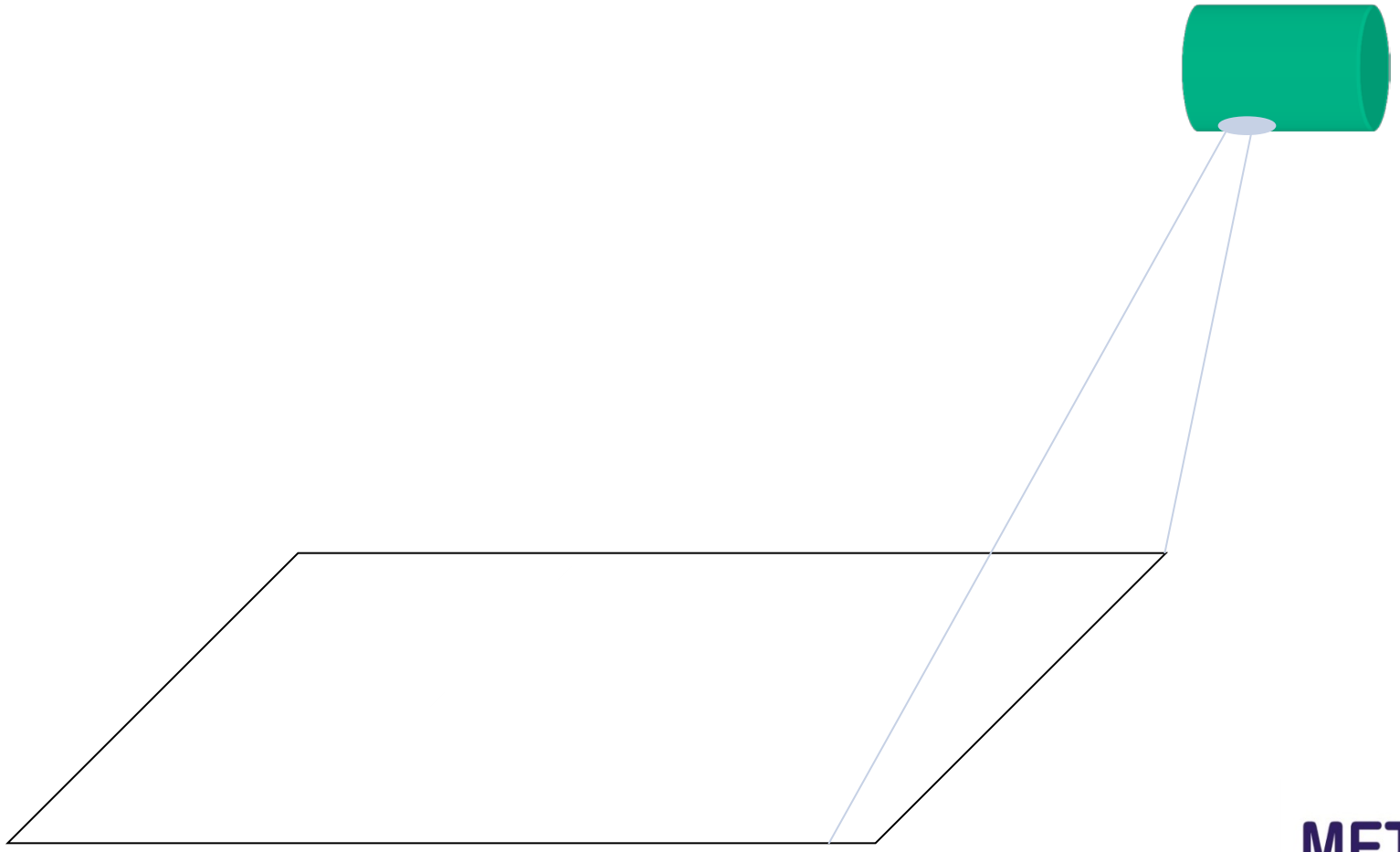


- Rotating Telescope Scanner covers the large operational FOV of 110° (2800 km swath)
- Principle of operation: a half-angle mirror at half rotation rate produces a standing image on the focal plane
- Reflective three mirror telescope, covers large spectral range from VIS to thermal IR

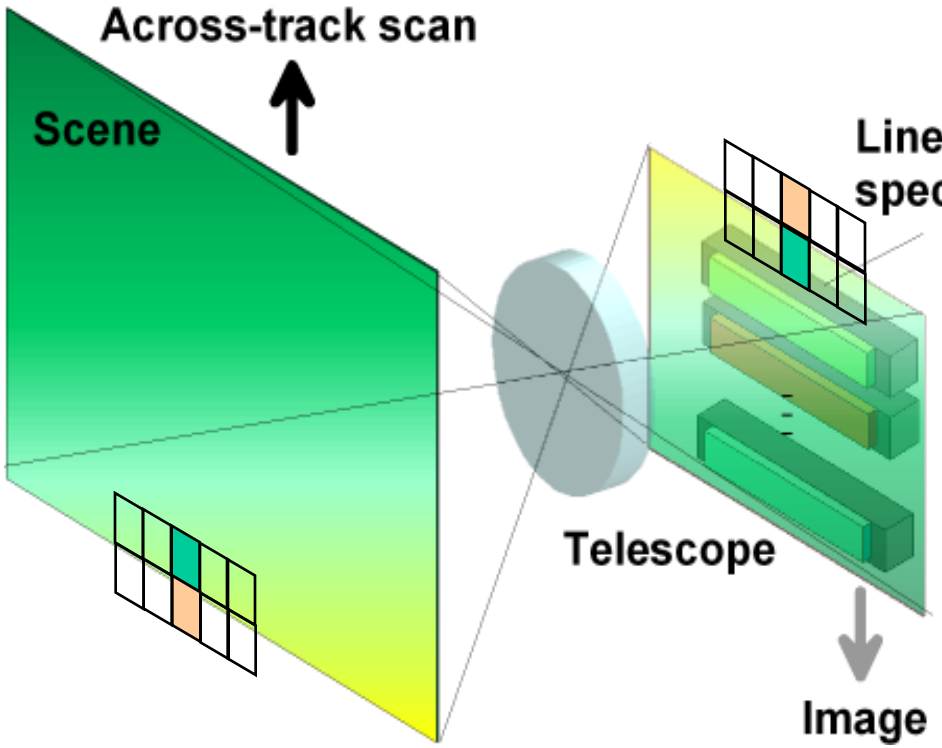


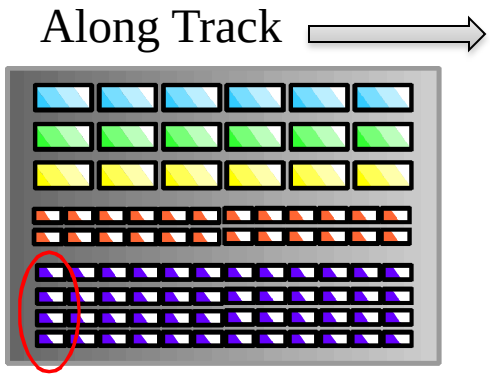
- Several calibration sources are located outside the earth FOV and are measured with every telescope rotation
- Allows short term calibration without disruption of measurement cycle

METimage – ground coverage by rotating telescope scanner



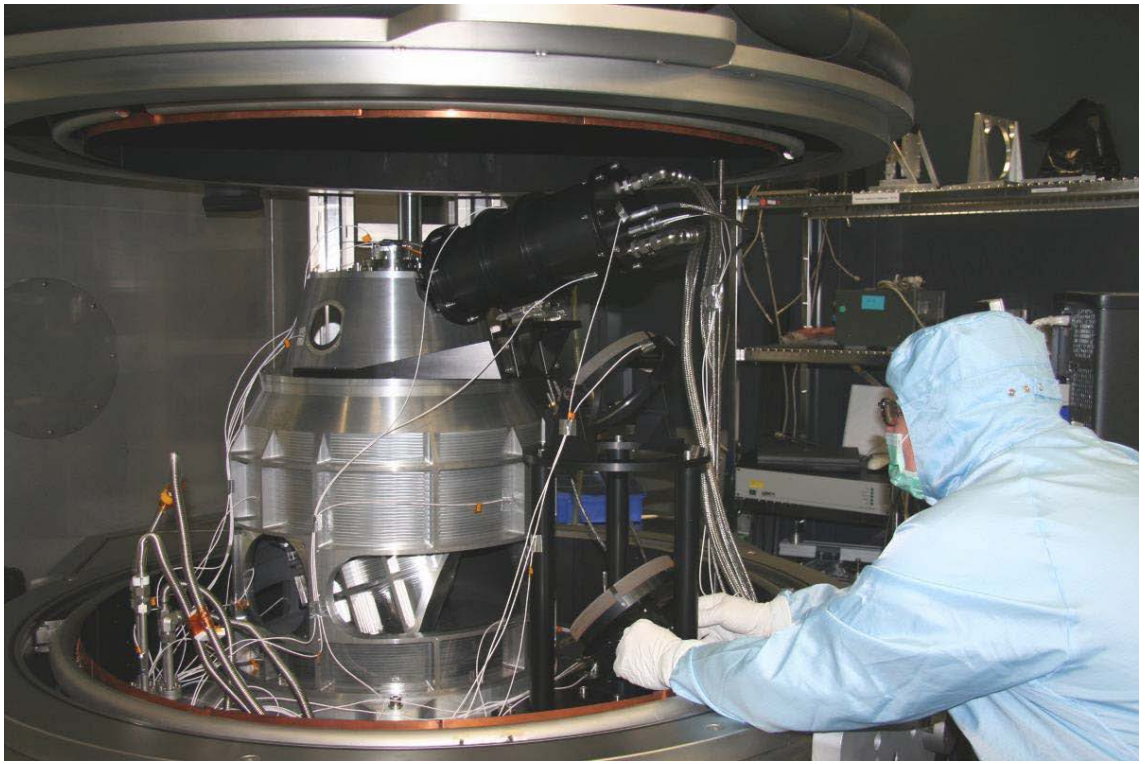
METimage - FPA: In-field Separation of Spectral Channels





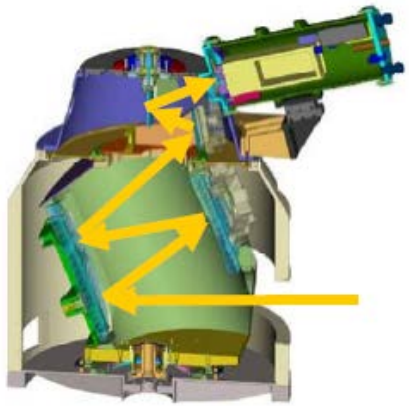
- Time delayed integration (TDI)
  - Multiple exposures within one band
- Different pixel sizes
  - Different spatial resolution

METimage – Rotating Telescope Breadboard



Demonstrator in test set-up in the TVC

- ✓ demonstrator of the rotating telescope scanner as core assembly of the METimage instrument
- ✓ Manufacturing and integration of mirrors into stable rotating subassemblies with low resulting moments of inertia
- ✓ Motor control and synchronisation of HAM and rotating telescope motion

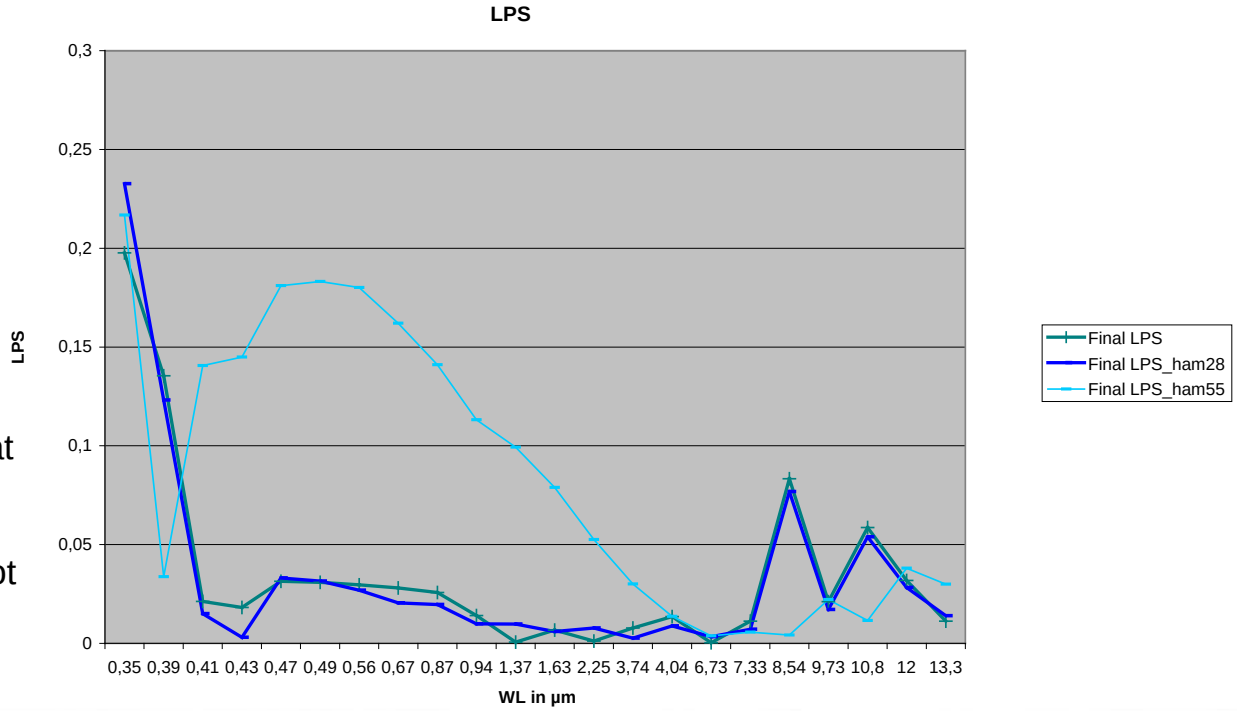


METimage - performance requirements

- Co-registration: 87% (incl. 30% margin) √
  - Co-registration errors occur within a single focal plane or by misalignment between different focal planes
  - Highest contributors are thermo-elastic effects between FPs and adjustment error between channels and FPs

- Polarisation:
- < 5% for VIS √
- < 11% for IR √

Note: VIS/SWIR polarisation at 55° (calibration position) is looking at unpolarised calibration source and does not contribute to polarisation budget

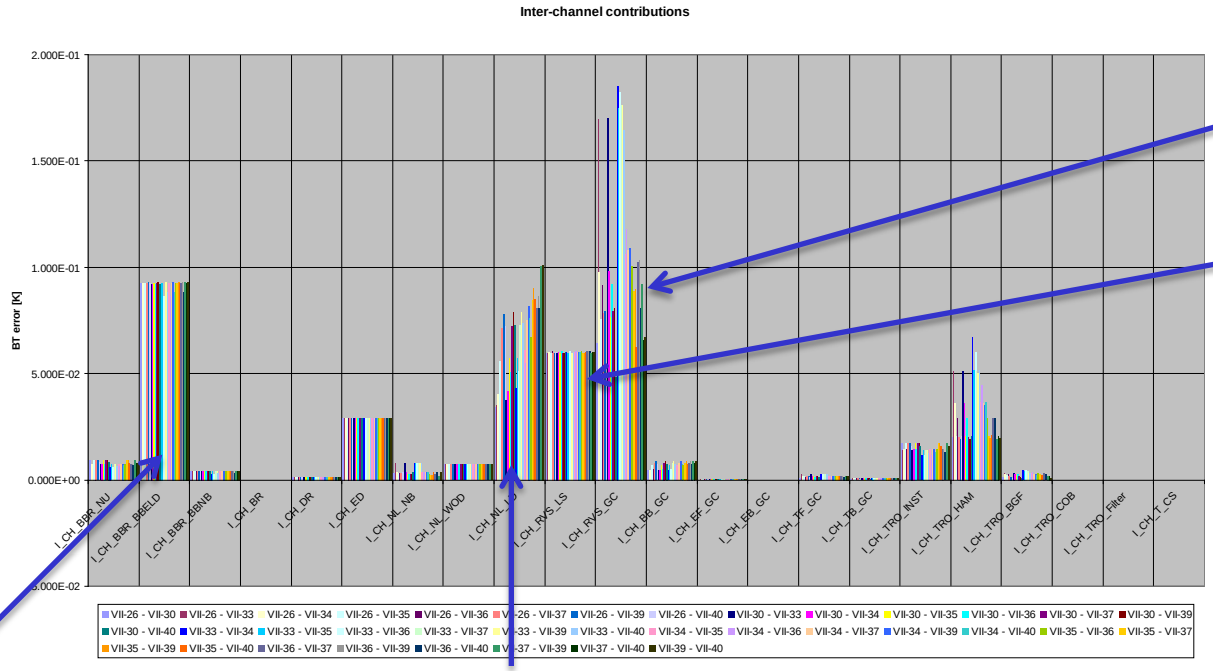


METimage - predicted radiometric performance: Thermal Bands

- Sensitivity analysis for thermal bands has been elaborated
  - Strong contributors to the overall error budget can be identified
  - Channel dependent error budgets
  - Values for thermal bands are strongly wavelength dependent

	Within Orbit stability	**Lifetime stability**	**Bias accuracy**	**Inter-spatial uniformity**	**Inter-channel uniformity**
Analysis *best* Value *worst*	< 0.1 K	0.11 K 0.13 K	0.22 K 0.27 K	0.1 K 0.2 K	0.18 K 0.28 K
With 30% Margin	< 0.15 K	0.14 K 0.17 K	< 0.5 K	0.13 K 0.26 K	0.23 K 0.36 K
Required Value	0.15 K √	0.15 K √	0.5 K √	0.1 K	0.1 K

METimage - example for wavelength dependent error budget: inter-channel uniformity error contributions



RVS Ground Characterization

RVS lifetime stability

BB emissivity
Lifetime stability

Detector Non-linearity
Lifetime stability

Note: At a $T_{typical}$ = 300K a ΔT = 0.10 K in VII-37 (10 µm) corresponds to a relative change of 0.15 %
(compare to 1 % requirements for solar bands!)

METimage predicted radiometric performance: Solar Bands

		Within Orbit stability	Lifetime stability	Bias Accuracy	Inter-spatial uniformity	Inter-channel Uniformity
Analysis value	RSS	0.7 %	0.6 %	2 %	0.5 %	2 %
	lin. sum			4 % (WC)	1 % (WC)	4 % (WC)
With 30% margin		< 1%	< 1%	2.6 %	0.65 %	2.6 %
				5.2 %	1.3 %	5.2 %
Required value		1 % √	1 % √	5 % √	1% √?	1%

WC: worst case estimates
all numbers to be updated with wavelength dependent analysis for solar channels

METimage – MTF

- Image quality is defined by a MTF requirement
  - Max imaging capability for frequencies below Nyquist (MTF >0.3 @ f/f_nyq = 1) ✓
  - Min imaging capability for frequencies above Nyquist to avoid aliasing (MTF < 0.1 @ f/f_nyq = 1.50)

- Anisotropy in MTF between ALT and ACT directions due to the motion blur in the scanning direction, which degrades MTF ACT
- MTF ALT is “too good” at higher spatial frequencies
- MTF aliasing: non-compliant for ALT in the IR
  - modified detector read-out scheme could fix problem for channels without micro-lenses (VIS channels)
  - In the IR micro-lenses would be needed to reach the requested SNR and to realise the requested number of channels on the FP

- Need for antialising requirement in the IR region and technical solutions to fix the problem under investigation

- Nyquist frequency defined as 1/(2*SSDnadir)

METimage - datarate

Data rate	Day [Mbit/s]	Night [Mbit/s]
Peak with margin	57.0	19.8
Peak without margin	51.8	18.0
Mean with margin	19.5	6.8
Mean without margin	17.7	6.1

Predicted data rate for10 Solar bands (including 2 spatial high resolution bands) and 10 Thermal Bands
“Mean” = averaged over a rotation

MET*image* – next steps

- System Requirements Review passed
- Start of phase B2 is planned for beginning of 2012
- Negotiation of cooperation agreement with EUMETSAT within next months