10th IRS Mission Advisory Group Meeting

Update on IRS Geometric Performances from MTG-S Satellite CDR

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10th IRS-MAG meeting – Geometric Performances (1/9)

- The IRS geometric performances relate to the following categories:
  a. Coverage & clipping requirements
  b. Dwell overlap & repeatability requirements
  c. Line of Sight stability requirements
  d. Spatial sampling requirements (SSD, SSE)
  e. Inter-band co-registration requirement (RSPE)
  f. Geolocation requirements (ASPKE, RSPKE, IDNE)

- Categories a. to e. are realization requirements to be met at satellite level once all the biases are calibrated in-flight

- Category f. are knowledge requirements at system level, i.e. taking into account the Image Navigation & Registration (INR) ground processing

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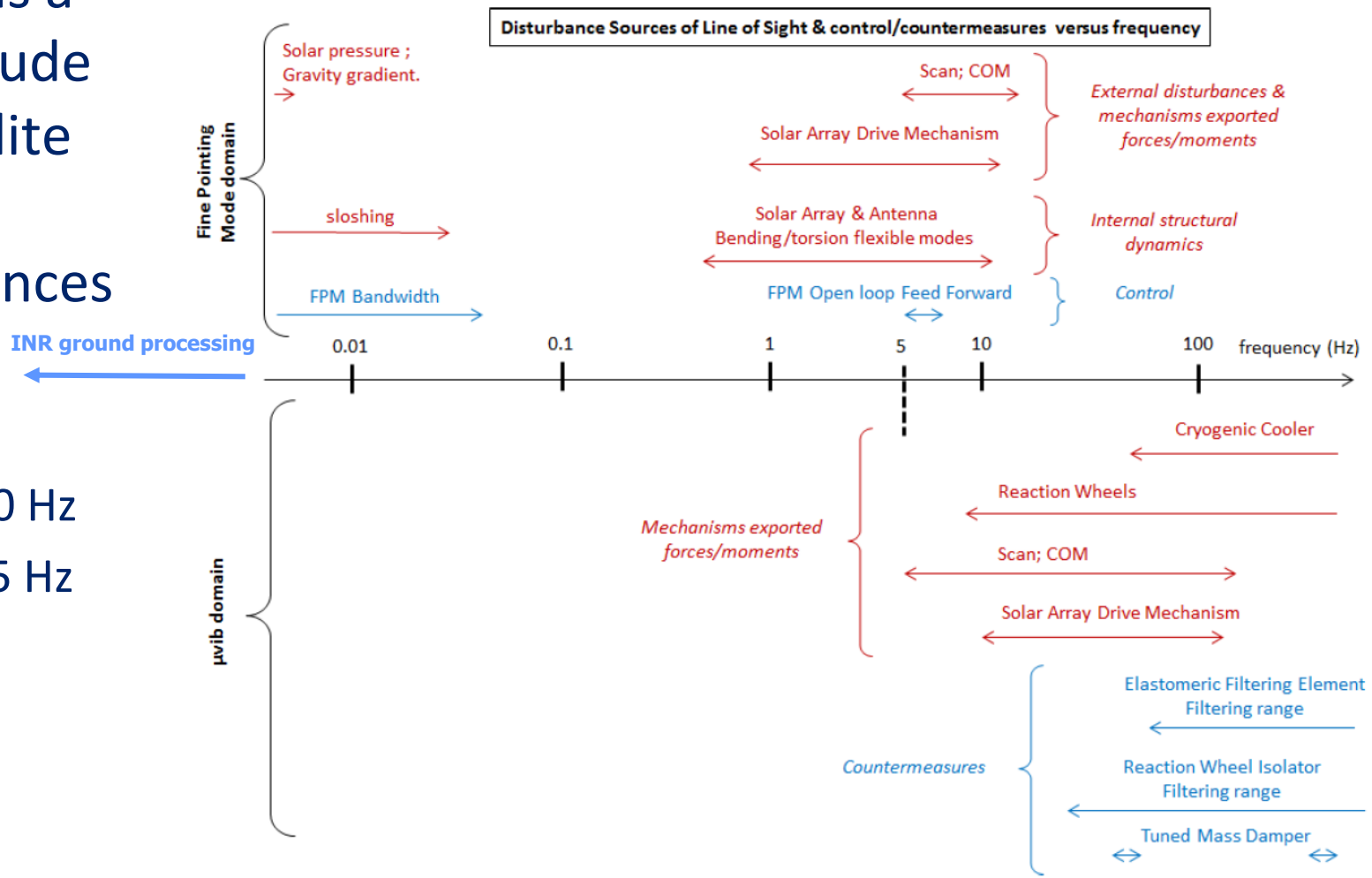
- Fine Pointing Mode (FPM) is a mode of the orbit and attitude control system of the satellite

- Line of Sight (LOS) disturbances are shared between:
  - INR domain < 0.002 Hz
  - 0.002 Hz < FPM domain < 10 Hz
  - Micro-vibrations domain > 5 Hz



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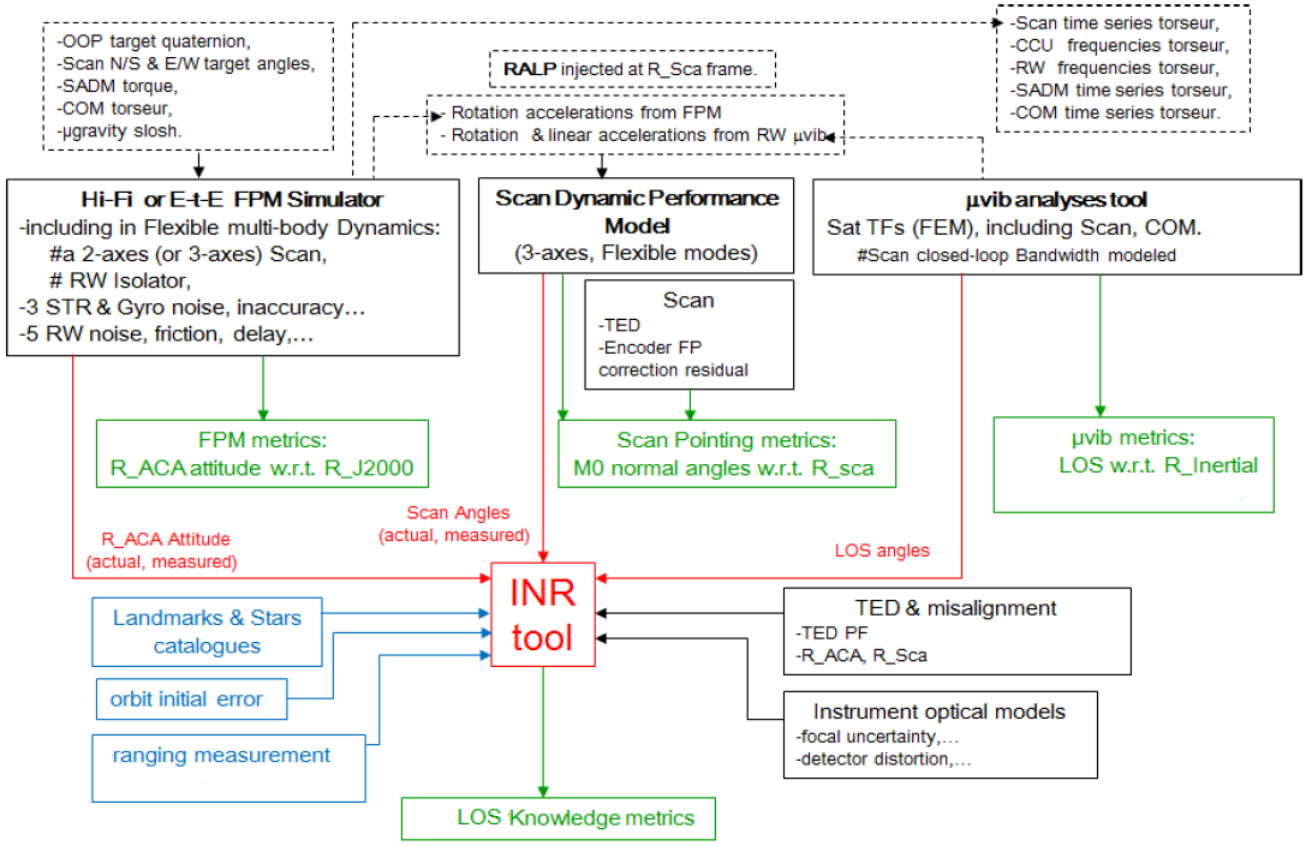
- How were INR performances established for MTG-S Satellite CDR?
  - Numerical models are used to simulate the platform FPM attitude, the scan angles and the micro-vibrations transmitted to the LOS
  - Platform attitude and scan angles time series, LOS model and INR ground processing emulator (INR tool) are used to derive the INR performances at Level 1
  - FPM, scan and most of the micro-vibrations data and models are correlated with equipment hardware test results



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- Absolute pointing and drift contribute to:
  - ✓ Coverage
  - ✓ Dwell overlap & repeatability
  - ✓ Integrated energy
- Pointing jitter contributes to:
  - ✓ Line of Sight stability
  - ✓ Integrated energy

Jitter related budgets account for the latest micro-vibration analysis (x2) provided at the MTG-S CDR colocation

Budget at MTG-S CDR Requirement Type	Specification [km @ SSP]		Performance [km @ SSP]		Margin	
	NS	EW	NS	EW	NS	EW
Apportionment of PL-IRS-080 – Coverage – to Absolute Pointing Error (APE)	<21.1	<33.3	17.6	18.9	17%	43%
Apportionment of PL-IRS-090 – Dwell Overlap – to Pointing Differential Error (PDE) over 10s in EW or 400s in NS	<16.0	<12.0	3.1	0.8	81%	93%
Apportionment of PL-IRS-100 – Dwell Repeatability – to Pointing Differential Error (PDE) over 30 min.	<30.5	<19.0	13.4	5.3	56%	72%
Apportionment of PL-IRS-300 – Integrated Energy – to Pointing Differential Error (PDE) over 9.7s	<0.42	<0.43	0.17	0.08	59%	81%

Budget at MTG-S CDR Requirement Type	Specification [km @ SSP]		Performance [km @ SSP]		Margin	
	NS	EW	NS	EW	NS	EW
Expression of PL-IRS-290 – LoS stability – as Relative Pointing Error (RPE)	<0.30	<0.30	0.17	0.29	44%	3%
Apportionment of PL-IRS-300 – Integrated Energy – as Relative Pointing Error (RPE)	<0.27	<0.29	0.21	0.40	21%	-38%

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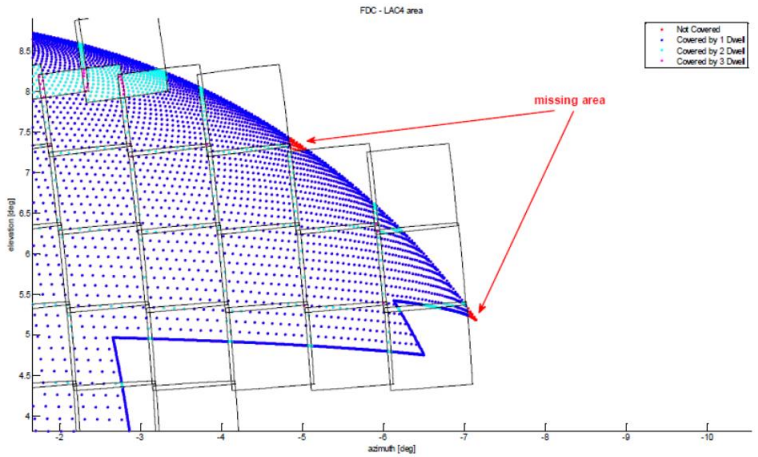
- Coverage & Clipping
  - ✓ Coverage with 0% clipping = full visible Earth surface above southern LAC boundary and/or below the northern LAC boundary
  - ✓ (Marginal) Non-Compliance from optimization of dwell pattern
- Dwell overlap
  - ✓ This is the overlap between adjacent dwells within a LAC
- Dwell repeatability
  - ✓ This is the percentage of coverage common to two dwells at the same position separated by two repeat cycles

Budget at MTG-S CDR Requirement Type	Specification [%]		Performance [%]	
	LAC4	LAC1-3	LAC4	LAC1-3
PL-IRS-030 – Coverage (clipping)	0	<4	0.9	3.3



Budget at MTG-S CDR Requirement Type	Specification [pixel]		Performance [pixel]		Margin	
	NS	EW	NS	EW	NS	EW
PL-IRS-090 – Dwell overlap	>4	>4	4.7	4.1	17%	3%

Budget at MTG-S CDR Requirement Type	Specification [%]	Performance [%]
PL-IRS-100 – Dwell repeatability	>92	97

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- Spatial Sampling Distance
  - ✓ The distance *d* between adjacent samples shall be $0.95 < d < 1.05$ SSD
  - ✓ Non-Compliance caused by optical distortions and sub-pixel de-selection (dominant)
- Spatial Sampling Error
  - ✓ Evaluate as the difference between the estimated grid (characterized on-ground) and the actual grid at 68% confidence level
- Co-registration
  - ✓ RSPE: *Relative Sample Position Knowledge Error* at 68.26% confidence level
  - ✓ Specified i) within a spectral band and ii) between spectral bands
  - ✓ Non-Compliance caused by alignment uncertainty and chromatism

These requirements are fully allocated to the instrument (i.e. no satellite or ground processing contribution), cf. IRS CDR status

Budget at MTG-S CDR Requirement Type	Specification [%]	Performance [%]
PL-IRS-270 – Spatial Sampling Distance	100	79

Budget at MTG-S CDR Requirement Type	Specification [m @ SSP]	Performance [m @ SSP]	Margin
PL-IRS-090 – Spatial Sampling Error	<200	186	14%

Budget at MTG-S CDR Requirement Type	Specification [m @ SSP]		Performance [m @ SSP]		Margin	
	NS	EW	NS	EW	NS	EW
PL-IRS-420 – Intra-band co-registration	<400	<400	345	302	14%	24%
PL-IRS-420 – Inter-band co-registration	<800	<800	984	935	-23%	-17%

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- INR performance scenarios

Case	Period	Scan & Duration	Manoeuvre / Orbit Determination	Orbit
Nominal	Winter time -9° sun elevation	Nominal IRS scan (winter configuration) over 24h starting at 0:00	No manoeuvre Nominal orbit data accuracy (without ranging measurements)	Inclination = 1° Eccentricity = 0.0004 Longitude = 0.05°
Eclipse	Spring equinox	Nominal IRS scan (winter configuration) over 24h starting at 0:00	No manoeuvre Nominal orbit data accuracy (without ranging measurements)	Inclination = 1° Eccentricity = 0.0004 Longitude = 0.05°
Yaw-flip manoeuvre (results from IDCP)	*Spring equinox*	*Nominal IRS scan (summer configuration) starting at 9:30 and ending at noon on the following day*	*Yaw-flip manoeuvre at 9:00 Nominal orbit data accuracy (without ranging measurements)*	*Inclination = 1° Eccentricity = 0.0004 Longitude = 0.05°*
NS manoeuvre recovery	Winter solstice	Nominal IRS scan (winter configuration) over 18h starting at 3:00	SKM ending at 2:30 Nominal orbit data (with ranging measurements) and delta-V accuracy	Inclination = 1° Eccentricity = 0.0004 Longitude = 0.05°
Increased landmarks visibility	Summer solstice	Nominal IRS scan (summer configuration) over 24h starting at 0:00	No manoeuvre Nominal orbit data accuracy (without ranging measurements)	Inclination = 1° Eccentricity = 0.0004 Longitude = 0.05°
High inclination (results from IDCP)	*Winter time -9° sun elevation*	*Nominal IRS scan (winter configuration) over 24h starting at 0:00*	*No manoeuvre Nominal orbit data accuracy (without ranging measurements)*	*Inclination = 2.5° Eccentricity = 0.001 Longitude = 0°*

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- INR simulation results
  - ✓ ASPKE: *Absolute Sample Position Knowledge Error* at 99.73% confidence level
  - ✓ IDNE: *Inter-Dwell Navigation Error* at 95.45% confidence level
  - ✓ RSPKE: *Relative Sample Position Knowledge Position Knowledge Error* at 99.73% confidence level

- Additional scenarios and sensitivity analyses are not showing any discrepancy or implying non-conformances at system level; e.g. recovery time after a manoeuvre

IRS nominal performances

SRD Req. ID	Req. Type	mode	Requirement (nominal) EW km	Requirement (nominal) NS km	Performance EW km	Performance NS km	Margin EW	Margin NS
PL-IRS-390	ASPKE over 1 LAC	MWIR	2,37	2,37	1,24	1,00	48%	58%
		LWIR	2,37	2,37	1,31	0,96	45%	59%
PL-IRS-400	ASPKE over 1 dwell	MWIR	3,32	3,32	1,46	1,24	56%	63%
		LWIR	3,32	3,32	1,53	1,17	54%	65%
PL-IRS-410	IDNE	MWIR	2,00	2,00	1,15	0,84	43%	58%
		LWIR	2,00	2,00	1,19	0,84	41%	58%
PL-IRS-430	RSPKE between images	MWIR	3,15	3,15	1,03	0,94	67%	70%
		LWIR	3,15	3,15	1,03	0,95	67%	70%
	RSPKE between spectral bands (for info)	LWIR/ MWIR	0,80	0,80	0,27	0,26	66%	67%

IRS eclipse performances

SRD Req. ID	Req. Type	mode	Requirement (nominal) EW km	Requirement (nominal) NS km	Performance EW km	Performance NS km	Margin EW	Margin NS
PL-IRS-390	ASPKE over 1 LAC	MWIR	2,37	2,37	1,39	1,03	41%	56%
		LWIR	2,37	2,37	1,32	1,01	44%	57%
PL-IRS-400	ASPKE over 1 dwell	MWIR	3,32	3,32	1,65	1,26	50%	62%
		LWIR	3,32	3,32	1,58	1,25	52%	62%
PL-IRS-410	IDNE	MWIR	2,00	2,00	1,15	0,86	42%	57%
		LWIR	2,00	2,00	1,15	0,86	43%	57%
PL-IRS-430	RSPKE between images	MWIR	3,15	3,15	1,06	1,09	66%	65%
		LWIR	3,15	3,15	1,06	1,10	66%	65%
(PL-IRS-420)	RSPKE between spectral bands (for info)	LWIR/ MWIR	0,80	0,80	0,29	0,28	64%	65%

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- Overview of geometric performances at MTG-S CDR (before close-out)

IRS Geometric Image Quality			Status
coverage	PL-IRS-80	PC	IRS CDR: clipping C, Lac 4 small NC for west scenario (few points missing on earth rim under worst case conditions). RFD: MTG-KT-IR-RFD-0216
dwell overlap	PL-IRS-090	C	IRS CDR: NC at instrument level, C at system level expected
dwell repeatability	PL-IRS-100	C	IRS CDR: C on instrument level, C on system level C w margin expected
Spatial Sampling Distance	PL-IRS-270	NC	IRS CDR: C for ~80% of the pixels (Typical: 90%). Reasons for NC are sub pixel deselection and optical imperfections. No MTG-S system level contributions. MTG-KT-IR-RFD-0220 (Class A) raised
Spatial Sampling Error	PL-IRS-280	C	IRS CDR: compliance with small margin (~15m)
ASPKE LAC	PL-IRS-390	C	MTG-S CDR from analysis of nominal cases
ASPKE dwell	PL-IRS-400	C	MTG-S CDR from analysis of nominal cases
IDNE	PL-IRS-410	C	MTG-S CDR from analysis of nominal cases
RSPE (channel co-registration)	PL-IRS-420	PC	IRS CDR: Interband coregistration is NC for worst case when using IA DEA commitment values, Intraband coregistration is C. Typical performance would be C for both. MTG-KT-IR-RFD-0263, i2 (Class A) raised.
RSPKE (images)	PL-IRS-430	C	MTG-S CDR from analysis of nominal cases
Eclipse case	PL-IRS-440	C	MTG-S CDR from analysis of nominal cases