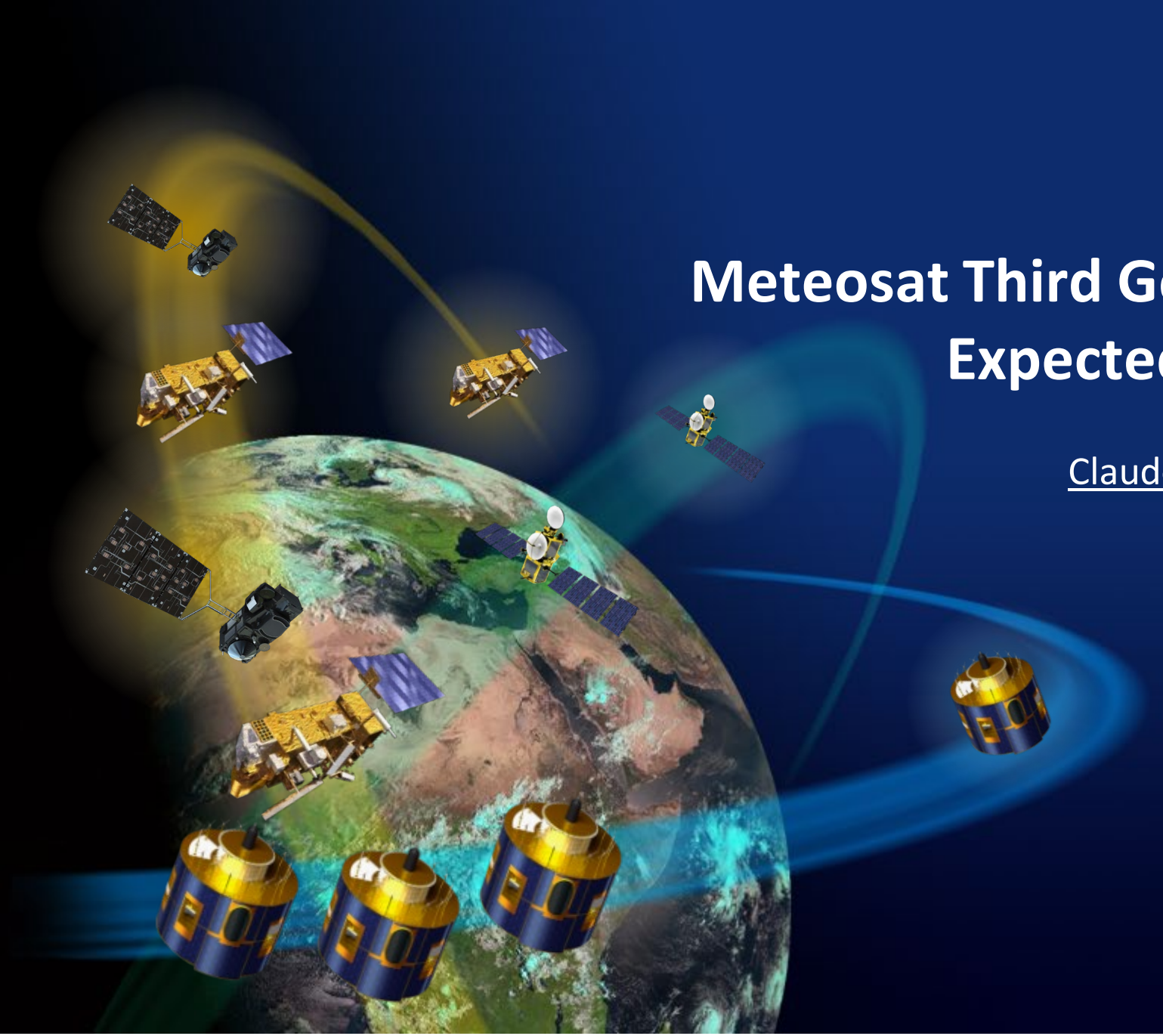


Meteosat Third Generation Lightning Imager Expected Navigation Performances

Claude Ledez, Mounir Lekouara, Johannes Müller,

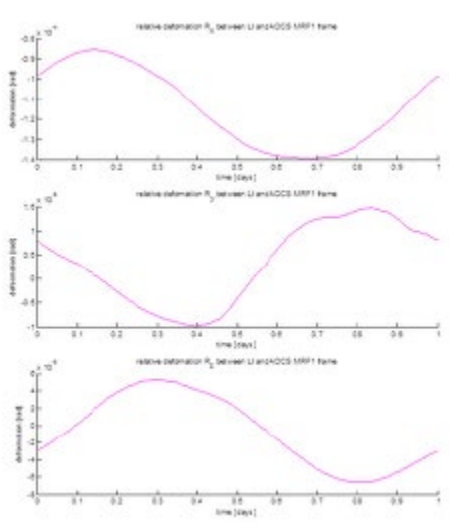
Steven Hadesty, Katja Hungershoefer

LI MAG meeting on RfDs, June 24-25 2020

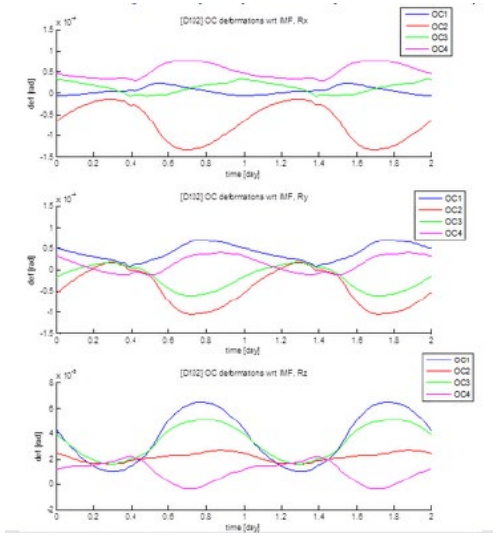
Outline

- Introduction
- Discussion
- Future work
- Conclusion

Introduction



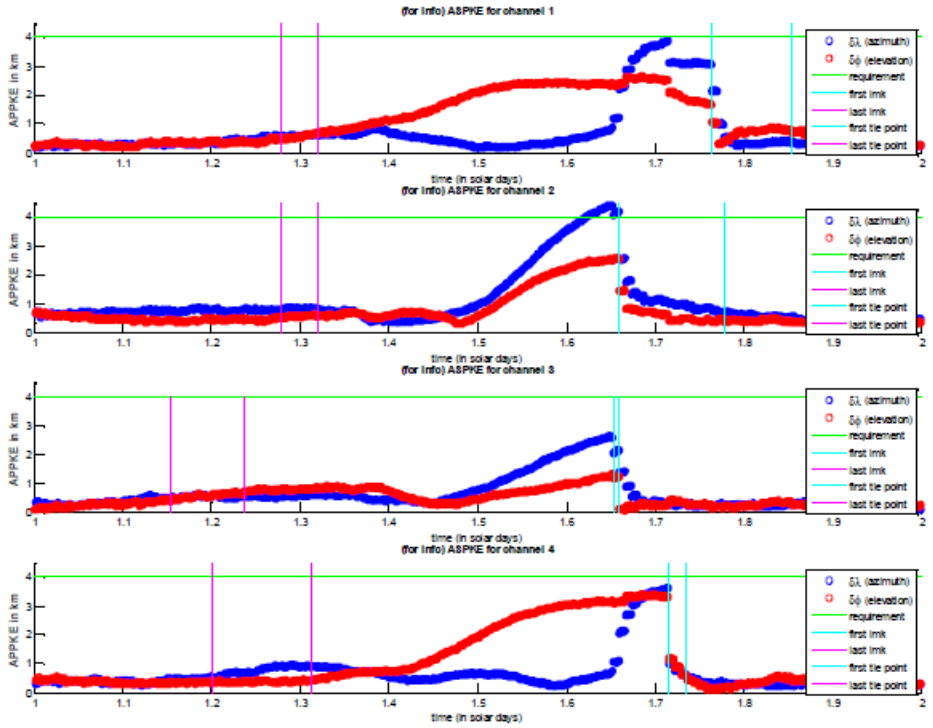
Platform TED at LI interface



LI Optical Channels TED

- The MAG has been presented the predicted LI navigation performance assessed by industry, see ESA's presentation p26-28
- The latest INR simulations correct some issues identified at MTG-I CDR, inputs:
  - ✓ New platform, FCI and LI Thermo-Elastic Deformations (TED) models accounting for latest LI design changes
  - ✓ New FCI scan encoder model
  - ✓ Simulation scenarios (both at day 102):
    i. FCI Full Disk Scan Service + LI
    ii. FCI Rapid Scan Service over Europe + LI

Discussion

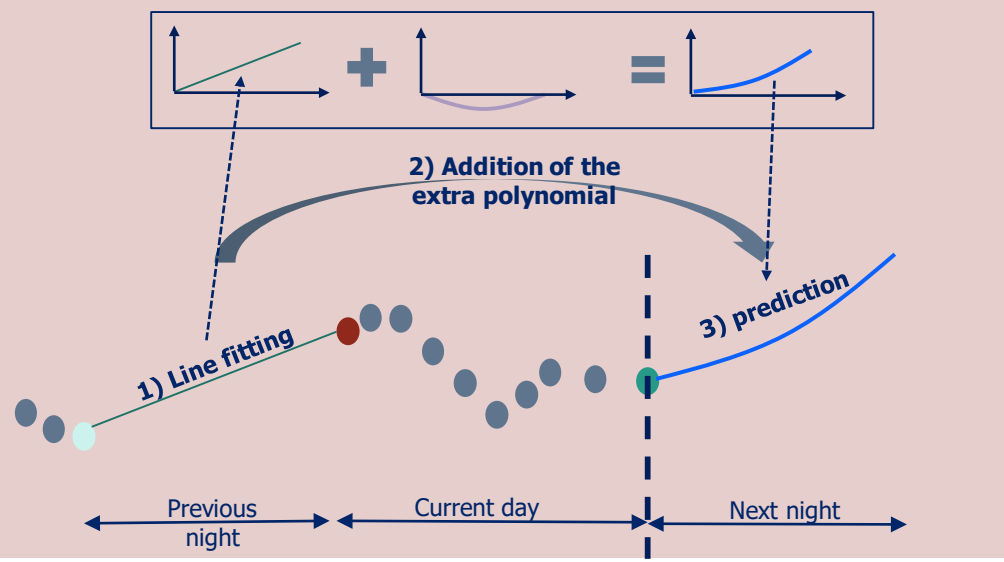


PL-LI-140	ASPKE LI	4,5	4,00	4,00	3,85	4,83	4%	-21%
(for info)	ASPKE OC#1				3,02	4,70		
	ASPKE OC#2				3,20	4,83		
	ASPKE OC#3				1,77	3,07		
	ASPKE OC#4				3,85	4,41		

- The measurement of the Absolute Sample Position Knowledge Error (ASPKE) and the tuning of the INR algorithm in the IQT are part of the Satellite In-Orbit Verification (SIOV) activities lead by ESA and industry
- The measurement of the ASPKE and the tuning of the INR algorithm in the IDPF are part of the System commissioning completed after SIOV
- Performance predictions at satellite level are derived from the INR runs (see figures and table on the left):
  - ✓ APSKE requirement met with good margins in daytime
  - ✓ ASPKE worst case occurs at the end of the night
  - ✓ At night, INR performance depends directly on TED
  - ✓ TED models are computed using numerical simulations; no uncertainty value available & no correlation with ground test

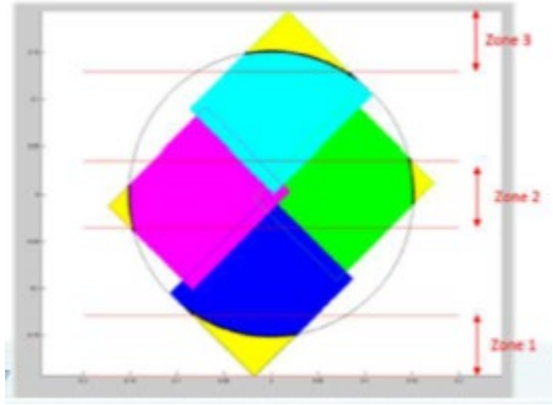
=> We aim at removing the non-compliance on ASPKE, related to a MTG-I CDR action, and mitigating the risk of larger TED in-orbit compared to the on-ground prediction

INR Design Improvement – Proposed Approach

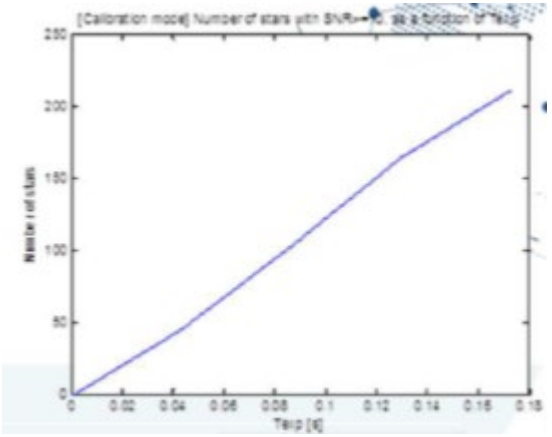


- EUMETSAT have been consulted by ESA about the approach for LI geolocation improvement during night
- The concept proposed by EUMETSAT and ESA to industry is to compensate the TED effect via the introduction of a feed-forward model of the Lightning Optical Head (LOH) attitude in the geolocation function
  - ❖ This predictive model has a polynomial component that is calibrated offline; it depends on the time of day and instrument temperature
  - ❖ This predictive model has an additional linear component that is computed online from the INR State Vector updates enclosing the past overnight period (see figure on the left)
  - ❖ In SIOV, the parameters of the predictive polynomial component will be set to zero => the compensation is linear
  - ❖ In commissioning, the parameters of the polynomial predictive component can be determined using stars (see following slide) or from correlation with LDN data (vicarious calibration)

Commissioning - Use of Stars



Stars observations areas (in yellow)



Cumulative number of stars over a day in the observation zones as a function of exposure time

Aim:

- ✓ To infer LOH attitude variation amplitude at night, i.e. when no landmark is visible

  ~1 star per hour and per OC needed to measure LOH attitude variation

- ✓ Considered as partial verification of ASPKE => not used for formal verification in SIOV:

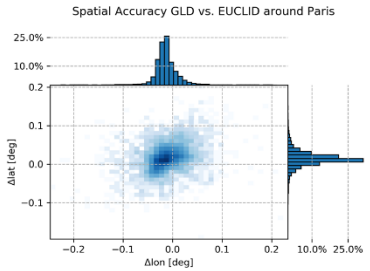
  Check if LOH attitude is in line with TED simulation in similar thermal environment

Satellite prime contractor activities during SIOV:

- ➢ Select 3 days: 1 day in solstice, 1 day in equinox and 1 day with sun at ±9°
- ➢ In the overnight period: acquire background data at increased integration time
- ➢ Match bright pixels (sub-pixel position of max brightness) with stars of sufficient SNR from star catalogue
- ➢ Compute difference in azimuth and elevation (instrument frame) between expected and observed positions

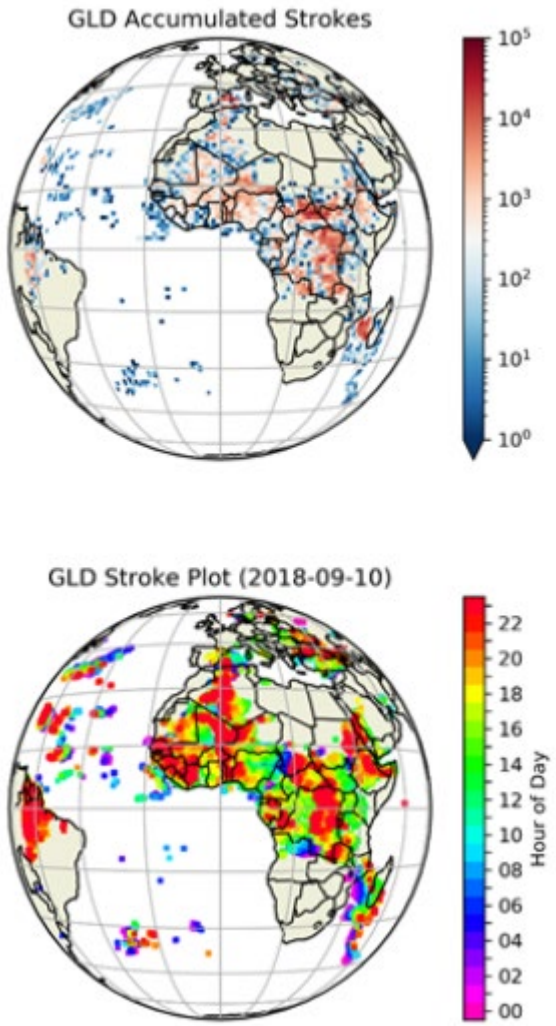
EUMETSAT activities during System commissioning:

- ➢ Correlate LOH attitude variation with (TBD) instrument temperature
- ➢ Correlate LOH attitude variation with LDN strokes vs. LI L2 groups geolocation error



EUMETSAT

Future Work



- At Space Segment Level:
  - TAS to review EUMETSAT/ESA proposal for the INR algorithm improvement before implementation in the IQT; updated ATBD needed by October 2020 for inclusion in IQT-I v3.5
- By EUMETSAT:
  - Injection of the IQT algorithm in IDPF (v5): algorithm review and discussion on operational implementation via the IDPF Algorithm Panel mechanism in December 2020
  - Update the INR Reference Processor to interfaces with the IDPF for getting the AOCS data (PF attitude), the MOF data (OBT-UTC, ranging, orbit) and the image observables (landmarks, stars)
  - Development of the offline monitoring function related to the INR (in progress) for commissioning
  - Verification of the LI navigation performances:
    - ✓ Use of realistic landmarks and stars errors gathered over years with MSG
    - ✓ Use of LDN flashes geolocation data for the calibration of the LOH attitude (see figure on the left)

Conclusion

- With the current INR design, the LI navigation performance differs between daytime and night-time (better during daytime, WC at the end of the night)
- The actual ASPKE in orbit may differ from the expected performance based on TED models
- Commissioning activity: verification of star residuals to get a sense of the correctness of the ground assumption on TED
- EUMETSAT involved early in the definition of the interface and the algorithm for the LI navigation at night at IQT level in the view of preparing the operational implementation
- The assessment of the navigation performances and the preparation of the offline performance monitoring and analysis tools for commissioning is in progress
- Matching with LDN (e.g. GLD360) will provide exogenous information of lightning groups geolocation allowing a vicarious calibration for LI navigation