Development of Compact Calibration Infrared Sources for the Meteosat Third Generation Flexible Combiner Imager

Mathieu Maisonneuve, Robert Bouchard, Manyuan Li, Yan Montembeault, Gaetan Perron, Jacques Giroux
A Legacy of Successful & Critical Flight Hardware

- SCISAT ACE-FTS
- SUOMI-NPP CrIS Sounder
- GOSAT-1 Tanso-FTS
- GOSAT-2 Tanso-FTS
- JPSS-1 CrIS-J1 Sounder
- JPSS-2 CrIS-J2 Sounder
- JPSS-3 CrIS-J3 Sounder
- JPSS-4 CrIS-J4 Sounder
- TERRA MOPITT
- AURA TES
- SUOMI-NPP CrIS
- Confidential customer
- JPSS-1
- JPSS-2
- JPSS-3
- JPSS-4
- MTG FCI (F1)
- MTG IRS (F1)
- METOP IASI-NG (F1)
- MTG FCI F2, F3 & F4
- MTG IRS F2
- IASI-NG F2 & F3
- METImage F2 & F3
- METImage (F1)
A broad spectrum of solution

Trends in weather and climate Earth Observation missions

Leading national program
- NOAA / NASA
- EUMETSAT / ESA
- ...

Smaller national program
- University based microsatellite.
- Emerging country space agencies.
- Concept missions.

Commercial Earth Observation mission
- Digital globe
- Rapid Eye
- Many others coming...

New platforms
- Low altitude drones
- High altitude stratospheric platforms

But, these missions to be useful must provide traceable data. They need calibration systems too.
Trends in weather and climate Earth Observation missions

A broad spectrum of solution

- Smaller national programs
- Commercial Earth Observation missions
- New platforms

Key requirements

- Compact
  - Constellation missions
  - Smaller platforms
- Low cost
  - New era of space 2.0
  - Cost reduction by doing constellation mission
- Same resolution as conventional system
  - Same SNR
  - Scale could vary
- Data useable by same users
  - Same level of post-processing
  - Inter comparison of data between systems
  - Traceability of data
## Trends in weather and climate Earth Observation missions

Same trends applies to calibration sources

<table>
<thead>
<tr>
<th>Compact</th>
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</thead>
<tbody>
<tr>
<td>• Constellation missions</td>
<td>• Low volume allocation</td>
</tr>
<tr>
<td>• Smaller platforms</td>
<td>• Low mass allocation</td>
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<table>
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<th>Low cost</th>
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<td>• New technologies for coating, sensors, reading electronics</td>
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<td>• Mass production to reduce cost</td>
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<tr>
<th>Same resolution as conventional system</th>
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<td>• Same SNR</td>
<td>• Emissivity in the same order of high end missions</td>
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<td>• Scale could vary</td>
<td>• Good accuracy in temperature knowledge</td>
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<th>Data useable by same users</th>
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<td>• Same level of post-processing</td>
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<td>• Inter comparison of data between systems</td>
<td>• High performance calibration source</td>
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<td>• Traceability of data</td>
<td>• Traceability of tests</td>
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</table>
The beginning: MTG FCI program

Compact Infrared Calibration Sources

Compact
- Low volume allocation
- Low mass allocation

Low cost
- New technologies for coating, sensors, reading electronics
- Mass production to reduce cost

Same features as conventional system
- Emissivity in the same order of high end missions
- Good accuracy in temperature knowledge

Data useable by same users
- Reliability of the performances
- High performance calibration source
- Traceability of tests

Mass of the calibration source: 128g

This work was supported in part by the European Space Agency (ESA) funding through the Meteosat Third Generation (MTG) programme. The Blackbodies will be flying on six MTG series instruments.
Compact Infrared Calibration Sources

The beginning: MTG FCI program

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Data useable by same users
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- Emissivity higher than 0.995 for a baffle less system.
- Radiometric error less than 100 mK.
Compact Infrared Calibration Sources

The beginning: MTG FCI program

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Data useable by same users

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- Traceability of tests

- Two high precision temperature sensors with knowledge better than 20 mK.
- Three low precision temperature sensors with knowledge about 50 mK.
- Heater embedded in the design with fast thermal transition.
Compact Infrared Calibration Sources

The beginning: MTG FCI program

- **Compact**
  - Low volume allocation
  - Low mass allocation

- **Low cost**
  - New technologies for coating, sensors, reading electronics
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Calibration of Blackbodies

How To Provide Accurate Traceable Thermal Knowledge

<table>
<thead>
<tr>
<th>Measurement Equipment</th>
<th>High end bridge used in several NML.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute calibration of resistance references</td>
</tr>
<tr>
<td></td>
<td>Absolute calibration of SPRT</td>
</tr>
<tr>
<td>Conditioning Equipment</td>
<td>Good thermal and stable bath (&lt; 10 mK)</td>
</tr>
<tr>
<td></td>
<td>Thermal design of the system allowing good thermal transfer</td>
</tr>
<tr>
<td>Results of calibration campaign</td>
<td>MTG-FCI EQM campaign have shown a BoL temperature uncertainty less than 10 mK</td>
</tr>
</tbody>
</table>
# Radiometric Test Setup at ABB

Looking for an Emissivity with Precision as low as 0.002

<table>
<thead>
<tr>
<th>Radiometric Measurement</th>
<th>Emissivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radiance stability</td>
</tr>
<tr>
<td></td>
<td>Radiance uniformity</td>
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<tr>
<th>Radiometric Etalon Knowledge</th>
<th>5 mK absolute accuracy</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Thermal stability about 5 mK/ hour</td>
</tr>
<tr>
<td></td>
<td>Emissivity &gt; 0.9995</td>
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<tr>
<th>FTS Performances</th>
<th>8-14 µm with LN2 cooled MCT</th>
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<tbody>
<tr>
<td></td>
<td>NESR &lt; 2 nW/cm²/sr/cm⁻¹</td>
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<th>Thermal Environment Properties</th>
<th>1 K absolute accuracy</th>
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<th>Resulting performances</th>
<th>Radiance knowledge less than 50 mK.</th>
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<tr>
<td></td>
<td>Emissivity measurement accuracy less than 0.003</td>
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Compact Infrared Calibration Sources

The next step …

How to reduce cost?

- Smaller national programs
- Commercial Earth Observation missions
- New platforms
Compact Infrared Calibration Sources

… to the new generation compact calibration sources

- Low volume allocation
- Low mass allocation

Low cost
- New technologies for coating, sensors, reading electronics
- Mass and standardized production to reduce cost

Same resolution as conventional system
- Emissivity in the same order of high end missions
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Data useable by same users
- Reliability of the performances
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Use ABB Quebec site experience in mass production:
- More than 800 FTS instrument per year.
- More than 1000 LIDAR per year
- Expert in small production customized solutions for various applications
- 44 years of experience in high end optical systems
In this presentation we have shown insights of the MTG-FCI blackbody.
- Provide high end thermal calibration sources.
- Compact and low weight calibration source.
- Demonstrated performance and calibration using reliable and traceable test setup.

Following the development of such design, ABB is pursuing that effort in:
- Developing low mass, compact platform with high ends performances
- Rely more on the emerging technologies to:
  - Get higher performances in lower mass and volume.
  - Simplify the design.
  - Allow the production of calibration sources for possible constellation missions.