Greenhouse Gas Monitoring with Small Satellites at Airbus Defence & Space

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IAA-B10-1504;
10th IAA Symposium on Small Satellites for Earth Observation;
April 20-24, 2015; Berlin
Greenhouse Gas Monitoring with Small Satellites at Airbus DS

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1 Introduction
Greenhouse Gas Monitoring - CO$_2$ & CH$_4$

• Carbon dioxide (CO$_2$) and methane (CH$_4$) are the two most important anthropogenic (“manmade”) greenhouse gases and responsible for climate change.
• our knowledge about their variable natural and anthropogenic sources and sinks has significant gaps.
• Appropriate knowledge is a pre-requisite for a reliable prediction of the future climate of our planet.

[1] ESA; CarbonSAT Mission Requirements Documents (MRD); EOP-SMA/2232/PI-pi; Issue 1.Revision 2, 23 May 2013
1 Introduction
Greenhouse Gas Monitoring - Spatial Sampling & Coverage

- Satellites can add important missing information due to their global coverage.
- The first satellite instrument sensitive to near-surface CO₂ and CH₄ concentrations has been SCIAMACHY on ENVISAT.
- SCIAMACHY has already demonstrated that satellite observations of atmospheric methane provide important information on regional methane fluxes, and atmospheric CO₂ observations can help to identify deficits in current models and showed that signatures of strongly emitting regions can be detected and assessed over time.

[1] ESA; CarbonSAT Mission Requirements Documents (MRD); EOP-SMA/2232/PI-pi; Issue 1.Revision 2, 23 May 2013
1 Introduction
Greenhouse Gas Monitoring – High Spectral Resolution Required
1 Introduction
Greenhouse Gas Monitoring – “Small Satellite Missions” @ Airbus DS

• Sentinel-5P with the TROPOMI instrument measuring Air Quality (O₃) and CH₄
  → AstroBus M (AS250)

• CarbonSat with the GreenHouse Gas Imaging Spectrometer (GHGIS) dedicated to CO₂ and CH₄
  → Astrobus M (AS250)

• MicroCarb with an grating spectrometer focusing on CO₂
  → Astrobus XS (Myriade Evolution & AS250)

• MERLIN with an LIDAR instrument devoted to CH₄.
  → Astrobus S (Myriade Evolution & AS250)
1 Introduction
Platform Products @ Airbus DS

<table>
<thead>
<tr>
<th>Platform Segment</th>
<th>AstroBus XS*</th>
<th>AstroBus S*</th>
<th>AstroBus M</th>
<th>AstroBus L</th>
<th>AstroBus XL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity</td>
<td>Validated in Flight</td>
<td>First Launch in 2017</td>
<td>Validated in Flight</td>
<td>First Launch in 2017</td>
<td>First Launch in 2018</td>
</tr>
<tr>
<td>Typical Launch Mass</td>
<td>125 kg to 200 kg *</td>
<td>400 kg</td>
<td>900 kg</td>
<td>1500 kg</td>
<td>3000 kg to 4000 kg</td>
</tr>
<tr>
<td>Typical Payload Mass / Power</td>
<td>&lt;70kg / &lt;70 W</td>
<td>150 kg / 150 W</td>
<td>250 kg / 250 W</td>
<td>500 kg / 250 W</td>
<td>1100 kg / 1500 W</td>
</tr>
<tr>
<td>Lifetime</td>
<td>5 years</td>
<td>10 years</td>
<td>10 years</td>
<td>10 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Selected for</td>
<td>![Images of satellites]</td>
<td>![Images of satellites]</td>
<td>![Images of satellites]</td>
<td>![Images of satellites]</td>
<td>![Images of satellites]</td>
</tr>
</tbody>
</table>

(*): cooperation with CNES (Myriade and Myriade Evolutions series)

See also: IAA-B10-0104

AstroBus S, the high performance and competitive Small Satellites platform for Earth Observation
Patrick Lelong (1), Christophe Lemercier (2), Jean Cheganças (3)
2 Sentinel 5P
The Mission

It is a joint initiative between ESA and Netherlands providing the TROPOMI UV-VIS-NIR-SWIR instrument.

Gap filler/Precursor to be launched 2016
• after SCIAMACHY on Envisat up to the launch of Sentinel-5 instrument onboard MetOp Second Generation
• 5 to 7 years nominal operations

operational measurement of
• ozone pollution (Air Quality)
• Methane (CH$_4$)

atmospheric monitoring at high temporal and spatial resolution

Illustration of the 7x7 km2 footprint of TROPOMI as compared to heritage instruments. The TROPOMI spatial resolution is indicated with the red box

2 Sentinel 5P
Key Observation Parameter

Spectral Range
• 270-495 nm (UVS),
• 710-775 nm (NIR),
• 2305-2385 nm (SWIR3)

Swath and Spatial Resolution
• To allow daily global coverage
  – the swath is 2500 km with
  – 7x7 km² pixels
2 Sentinel 5P
Instrument and Platform – Key Budgets

**Instrument Budgets**
- 235 kg
- 160 W (nom ops.) - 380 W (decontamination)

**Platform**
- 600 kg P/F dry mass
- about 80 kg fuel
- 210 W (mean consumption)
3 CarbonSat
The Mission

Candidate ESA Earth Explorer 8 Mission
• Green House Gas
• 3-5 years nominal operations
• Launch date 2023

Identification of sources and sinks of
• Carbon Dioxide (CO2)
• Methane (CH₄)

high temporal and spatial resolution required
• To identify natural and anthropogenic sources and sinks
• To reduce impact of cloud coverage

Sun glint observation necessary over sea to get sufficient signal in the SWIR

CarbonSat will be operated in Nadir Mode over land and in sun glint mode over sea. When not in measurement mode then the platform performs sun bathing to maximize the battery charging.
3 CarbonSat

Key Observation Parameter

Spectral Range
• 747-773 nm (NIR),
• 1559-1675 nm (SWIR1),
• 1925-2095 nm (SWIR2)

Swath and Spatial Resolution
• the swath is 200 km with
• 2 x3 km² pixels

Sun glint observation
• Sun glint pointing could be performed by P/F pointing or by the instrument (additional scan mirror required)
3 CarbonSat
Instrument and Platform – Key Budgets

Instrument Budgets
• 180 kg
• 160 W (nom ops.) - 250 W (decontamination)

Platform
• 600 kg P/F dry mass
• about 80 kg fuel
• 210 W (mean consumption)
5 MicroCarb
The Mission & Key Observation Parameter

Candidate CNES Mission
• Carbon Dioxide (CO₂)
  medium spatial resolution
• For generating carbon flux maps on a monthly basis

Sun glint observation necessary over sea to get sufficient signal in the SWIR

Spectral Range
• 761-771 nm (NIR),
• 1563-1587 nm (SWIR1),
• 1925-2069 nm (SWIR2)
  – similar band location but significantly reduced spectral range compared to CarbonSat

Swath and Spatial Resolution
• 5 across track samples with
• about 3 x 9 km² pixels

Nadir Mode over land and Sun glint observation over sea.
5 MicroCarb
Instrument and Platform – Key Budgets

Instrument Budgets
• 65 kg
• 65 W

Platform
• 135 kg P/F dry mass
• 70 W (mean consumption)
5 MERLIN
The Mission (Methane Remote Sensing LIDAR Mission)

- CNES / DLR Mission
  - Currently in Phase B
  - CNES is responsible for
    - Operations
    - System
      - Airbus DS SAS contractor for the P/F
    - Launcher
  - DLR is responsible for the LIDAR Instrument
    - Airbus DS GmbH contractor for the P/L
- Accurate measurement of
  - Methane (CH₄)
- Objective:
  - global mapping of atmospheric Methane content (CH₄) and
  - Identification of Methane sources and drains.
5 MERLIN
Key Observation Parameter

**Laser Characteristics**
- NdYAG Laser
- 1645 nm (SWIR)
- 9 mJ transmit pulse energy
- 20-30 ns pulse length
- 12 Hz double pulse repetition rate

**Swath**
- 90 m laser spot size

**Dawn Dusk Orbit @ 500 km**

**Laser based on FULAS (Future Laser) project initiated by ESA**
- Laser inside pressurised housing to avoid laser induced contamination
5 MERLIN
Instrument and Platform – Key Budgets

Instrument Budgets
• 120 kg
• 150 W

Platform
• 280 kg P/F mass
• 400W (mean consumption)
6 Conclusion

At Airbus Defence and Space there are several Greenhouse gas monitoring instruments or missions under development or study.

Despite the complexity of the instruments the small satellite standard platform product family AstroBus is well suited for these missions.
Thank you for your Attention

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