MERLIN
Atmospheric Methane Lidar Mission


## Measurements of atmospheric methane from space

Climate change is one of the greatest challenges mankind has to face. Methane is one of the most powerful greenhouse gases. For a better understanding of climate change, it is necessary to apply precise space-based measurement techniques in order to obtain a global view on the complex processes that control the methane concentration in the atmosphere. CNES and DLR cooperate to develop and operate a space system dedicated to the measurements of methane sources and sinks. The name of the mission is MERLIN (Methane Remote Sensing Lidar Mission).
It is planned to launch the satellite in the time frame of 2024 with at least 3 years of operation in space.

### Mission Goals:

- Global information on atmospheric methane ($CH_4$) concentration (methane column density) with accuracy better than 2% and with a spatial resolution of 50 km along track also under cloudy and variable sun illumination conditions.
- The main data product will be column-weighted dry-air mixing ratio of $CH_4$.
- Improved knowledge on contribution to the atmospheric methane amount from energy production, wild fires, wetland changes due to climate change such as melting of permafrost soils and ocean sediments (gas hydrates).
- Improved understanding of $CH_4$ sources and sinks and their interactions with Earth climate.
- Improved data quality concerning anthropogenic and natural methane emissions.
- Contribution to computation of methane fluxes estimations.
- Significant contribution to climate change prediction.
- Contribution to control of the Kyoto protocol aims on methane emission regulation.
- Demonstrator for future satellite-based Integrated Path Differential Absorption (IPDA) LIDAR missions (LIDAR stands for Light Detecting and Ranging or “Laser Radar”.).
- Compliant with GCOS (Global Climate Observing System) monitoring principles.

### Mission Schedule:

Launch: in the time frame of 2024.
Minimum mission duration: 3 years.

### Orbit:

Polar, quasi circular sun-synchronous Earth orbit, with a mean orbit altitude of approx. 500 km and a Local Time of Ascending Node (LTAN) of 06:00 or 18:00.

### IPDA LIDAR Principle:

An IPDA LIDAR (light detecting and ranging) is an instrument that is able to determine the total methane column density between satellite and Earth surface or cloud top height. The methane amount is calculated from different absorptions at two laser wavelengths (on-line and off-line), reflected on Earth surface or cloud tops. Earth surface or cloud top reflected laser light is used because this is much more intense than backscattered light from aerosol particles in the atmosphere. The attenuation due to atmospheric methane absorption is strong at the on-line wavelength. The off-line “reference” wavelength is selected to be only marginally affected by methane absorption.

### Instrument concept:

MERLIN will be the first space-based integrated path differential absorption LIDAR instrument. It consists of a frequency stabilized high-power laser (20 Hz double pulse approx. 9 mJ pulse energy, wavelengths around 1.645 μm) as transmitter, and a receiver section consisting of an off-axis telescope (ø 690 mm) and a sensitive signal chain (baseline: InGaAs APD detector).

### Satellite:

Satellite platform: MYRIADE Evolutions
Satellite mass: approx. 430 kg
Satellite dimensions:
approx. 160×120×160 $cm^3$ with stowed solar panels
approx. 160×450×160 $cm^3$ with deployed solar panels
Satellite power consumption: maximum 500 W
Payload power allocation: approx. 150 W
Payload mass allocation: approx. 140 kg

### Launcher:

Auxiliary passenger on Soyuz or Vega launcher from Kourou in French Guiana.

### Mission Operation:

CNES satellite control centre with CNES ground station network for S-Band downlink for housekeeping data, S-Band uplink for commanding, and X-Band downlink for scientific data.

### Mission organisation:

The MERLIN climate mission is a joint French-German cooperation, performed by the national space agencies, CNES and DLR Space Administration.
Germany provides the IPDA LIDAR instrument. France provides its MYRIADE Evolutions satellite platform and its satellite control centre. CNES is mission prime and operates the satellite.
The system numerical simulator (Training Operation and Maintenance Simulator) is developed by CNES with DLR contribution and operated by CNES in Toulouse (France).
The Payload data processing centre is developed and will be exploited by CNES Toulouse space centre; Germany contributes with the development of the processor (Level 1) in charge of the instrument corrections.
Two Science Product EXpertise centres (SPEX) are developed; one in France and the other one in Germany.
Science activities are led by two Co-Principle-Investigators from the French laboratory from CNRS and the German Institute for Atmospheric Physics from DLR, with additional support of several French and German Research Institutes.
The satellite is developed by Airbus Defence & Space SAS (France), which will provide the MYRIADE Evolutions platform. Airbus Defence & Space GmbH (Germany), with contributions from German and French industries and German research institutes, will build the methane IPDA LIDAR instrument. The industries are under contracts by CNES and DLR Space Administration, respectively.
The German project part is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi).

### Mission Status:

The preliminary design phase has been finished successfully in 2016. The mission is now in the detailed design phase. Both CNES and DLR Space Administration have established industry contracts to build in particular the MERLIN satellite and payload. A contract with Arianespace has been signed to launch the MERLIN satellite.

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