the Spaceborne Wind Lidar Mission

AEOLUS
sense the wind

esa

ADM-Aeolus Industrial Consortium

AEOLUS sense the wind

Overall Prime Contractor:	EADS-Astrium (UK)
Aeolus Satellite:	EADS-Astrium (Germany)
ALADIN Instrument Prime:	EADS-Astrium (France)
Transmitter Laser Prime:	Galileo Avionica (Italy)
with subs Amplifiers:	Quantel (France)
Laser Diode Stacks:	Thales Laser Diodes (France)
Reference Laser:	TESAT (Germany)
Master Oscillator/Hamonics:	CESI (Italy)
ALADIN Optics:	Kaiser-Threde (Germany)
Receiver Interferometers:	Contraves (CH)
Accumulation CCDs:	e2v (UK)
Detection Front End Unit:	SIRA (UK)
Detection Electronics:	Patria (Finland)

plus about 20 other companies from ESA countries for various other instrument and satellite subsystems

EADS ASTRIUM

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ADM-Aeolus Mission Overview

The need for global measurements of wind profiles is well established.

ESA has been studying Wind Lidar technology since the eighties, and started a full Phase A mission study in 1998.

The Atmospheric Dynamics Mission was selected in Oct 1999 as second core mission of the Earth Explorer Program.

Predevelopment (instrument refinement, transmitter laser, laser diode stacks) started in 2000, and mission Phase B began July 2002, and Phase C/D Oct 2003. Launch planned for end 2008.

The Atmospheric Dynamics Mission ADM-Aeolus will demonstrate the feasibility of spaceborne wind lidars for global wind profiling and is a precursor for an operational wind profiler system.

Keep it simple:
Single Line-of-Sight wind profiles

- A study to define best scan strategy (Lorenc, 1992) resulted in understanding that improvement of Numerical Weather Prediction is nearly independent on direction of wind components measured, i.e. same improvement for two single direction vectors as for one 2-D vector (mainly the number of boundary conditions for NWP models counts)

> **The measurement of a single component (LOS) wind profiles simplifies wind lidar instrument design significantly:**

- No scanner required
- No lag-angle compensation
- Pointing orthogonal to ground velocity: no wind speed-offset due to satellite velocity
- Pointing to night side of orbit to reduce background

Aeolus System Requirements

Vertical resolution: 0.5 km to 2 km 1 km to 16 km 2 km to 30 km (total up to 25 layers)	Requires Mie and Rayleigh channel to measure over full altitude range
Horizontal average wind over 50 km Profile spacing 200 km to fit NWP needs	7 s averaging 28 s per observation
Global coverage (200 profiles per orbit) for three years in orbit	Drives lifetime qualification
LOS wind accuracy: 1 m/s up to 2 km 2 m/s up to 16 km	Drives sizing of lidar
Bias: less than 0.4 m/s offset Linerity: less than 0.7 %* actual speed	Drives stability of lidar calibration
Dynamic range: -150 to +150 m/s	

Consequences of the Aeolus System Requirements

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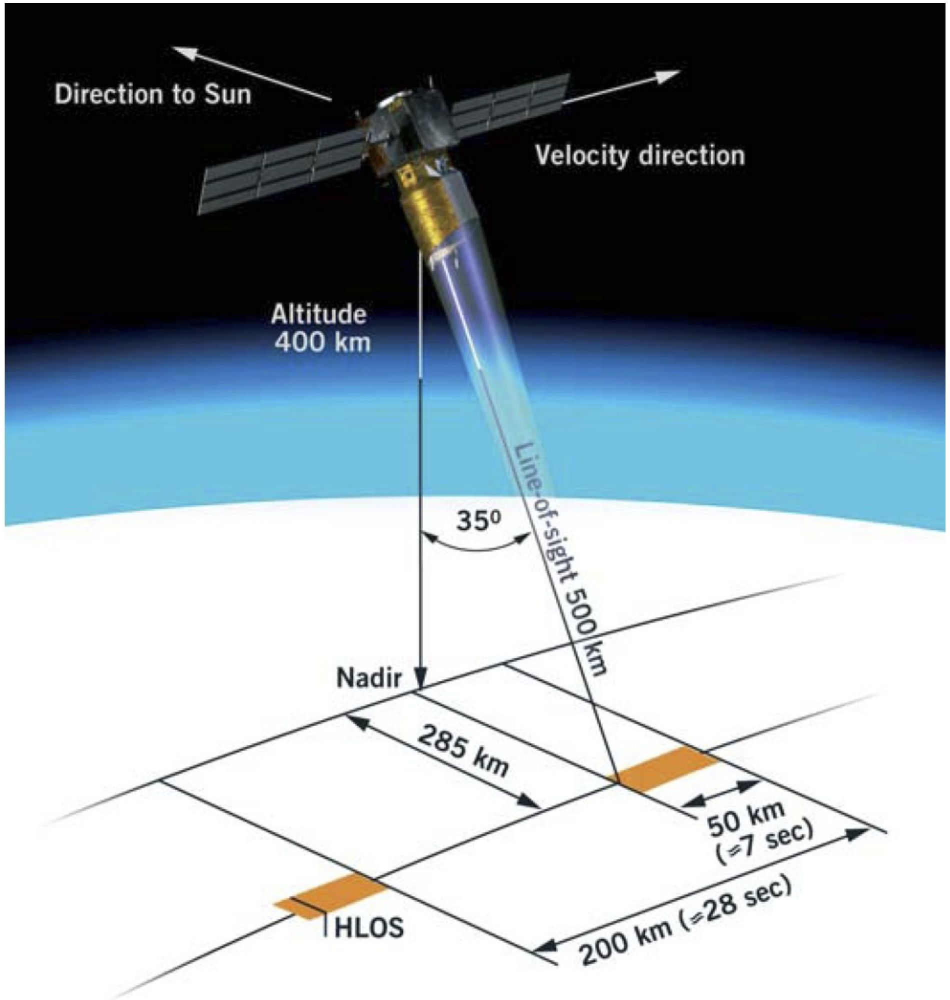
Trades were performed between potential lidar systems to meet the system requirements. Key contenders were

- **Coherent 2 µm solid-state laser system, and**
- **Incoherent 355 nm solid-state laser system.**

Requirement to measure high altitude winds was the key driver for decision for 355 nm incoherent system. High altitude wind patterns are considered key parameters for weather forecasts (in particular lower stratospheric winds), thus Rayleigh scattering is essential for these measurements, i.e. incoherent UV system.

Aeolus Implementation

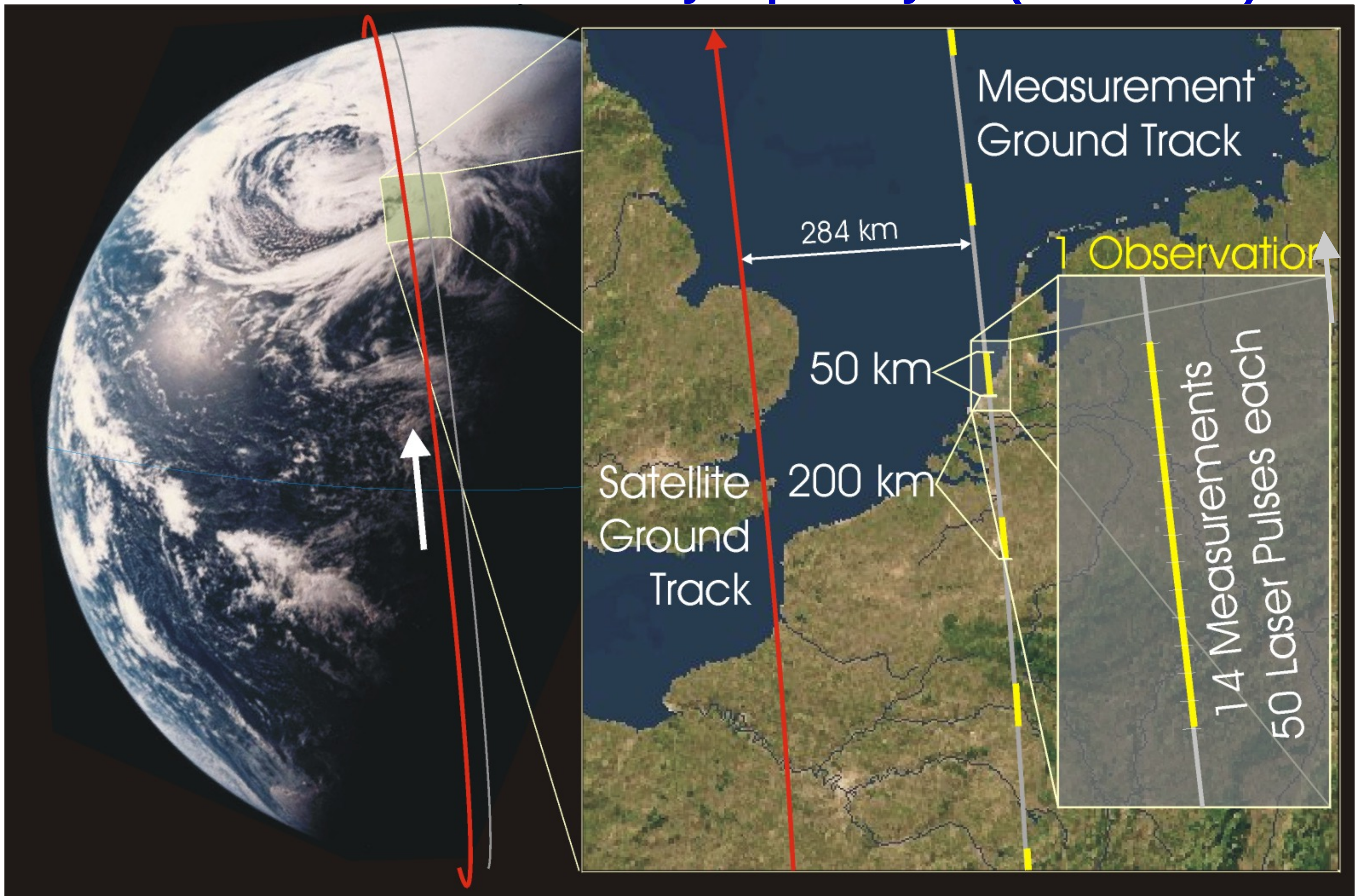


Baseline Technology:

- **Direct detection UV lidar (355 nm) with two receivers:**
- **Mie receiver to determine winds from aerosol backscatter**
- **Rayleigh receiver to obtain wind information from molecular backscatter of a clear atmosphere**
- **Mie and Rayleigh receivers can sample the atmosphere with different altitude steps**
- **The line-of-sight is pointing 35 deg from nadir orthogonal to the ground track velocity vector to minimize the Doppler shift from the 7 km/s satellite velocity**

Aeolus Orbit and Measurement Track

Aeolus is in a dusk-dawn sun-synchronous orbit of about 400 km altitude with a 7-day repeat cycle (109 orbits).

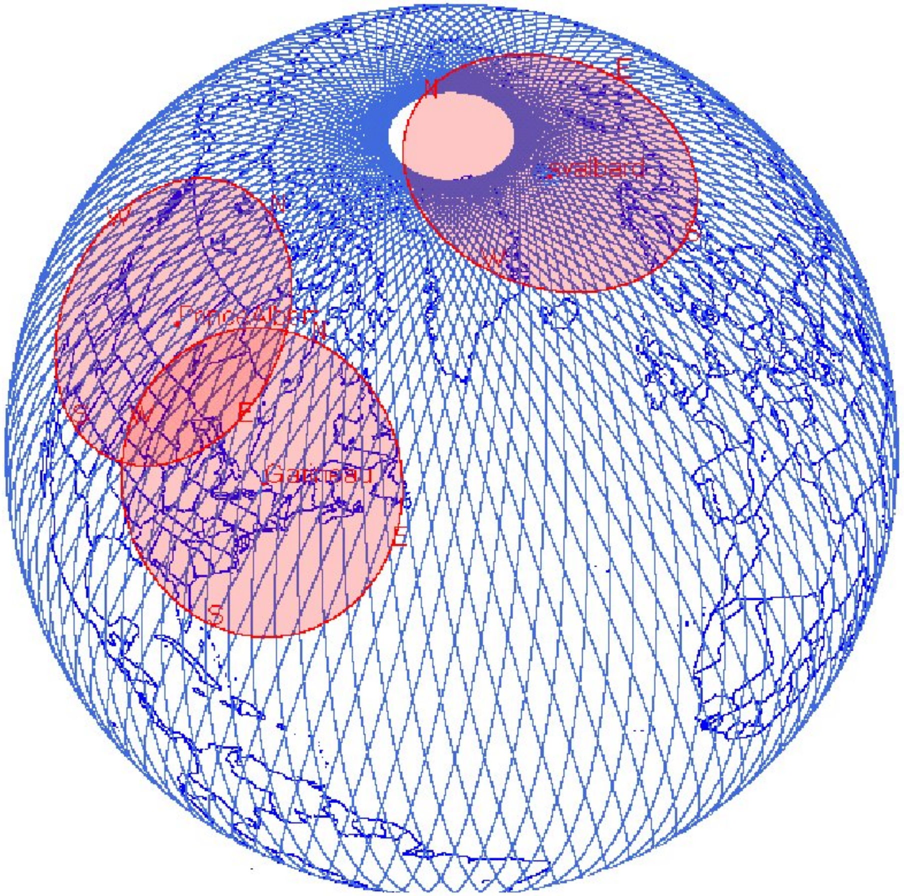


Aeolus measures HLOS-wind profiles averaged over 50 km observations (corresponding 7 s flight time).

The observations are 200 km apart (corresponding 28 s flight time).

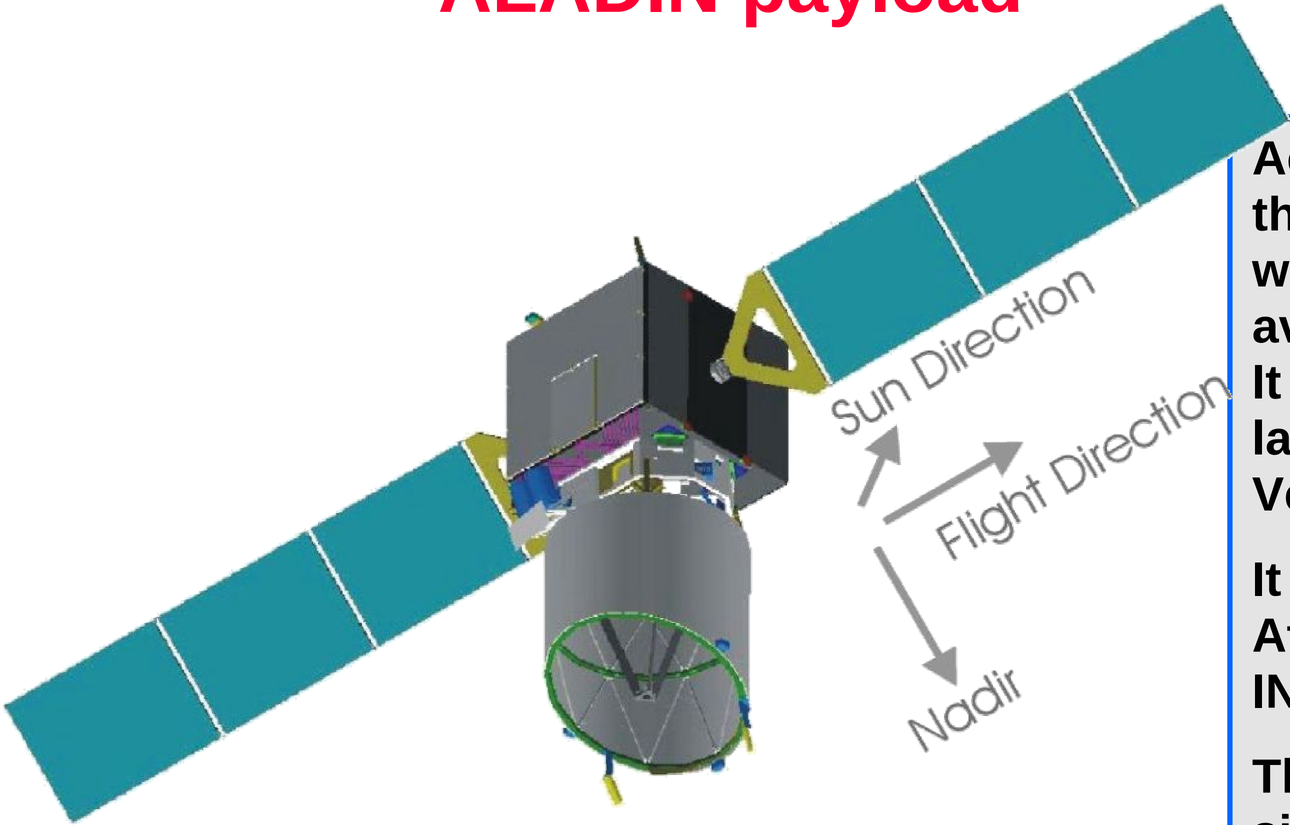
Picture shows the measurement track over 150 s duration.

Data Receiving Station Svalbard



Single data reception station in Svalbard allows downlink every orbit; Aeolus allows addition of fill-in stations to reduce data latency to 30 min for regional data.

Aeolus satellite with its ALADIN payload

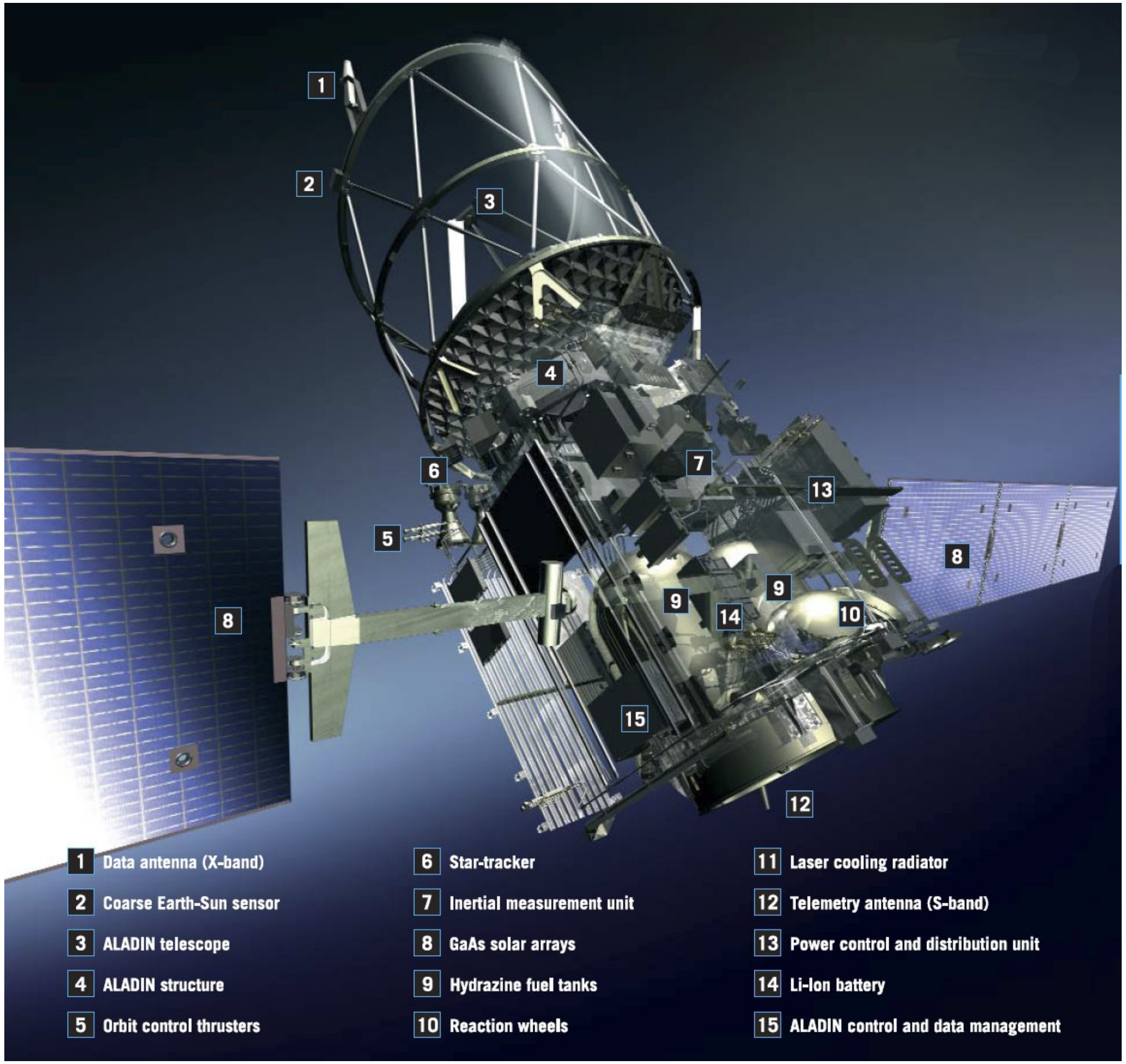


Aeolus mass is 1.1 t (plus fuel), the solar arrays are about 13 m wide to produce 2.2 kW (orbital average power 1.4 kW).
It is compatible with small launchers (Rockot, Dneper, Vega).

It carries a single payload, the Atmospheric LAser Doppler INstrument ALADIN.

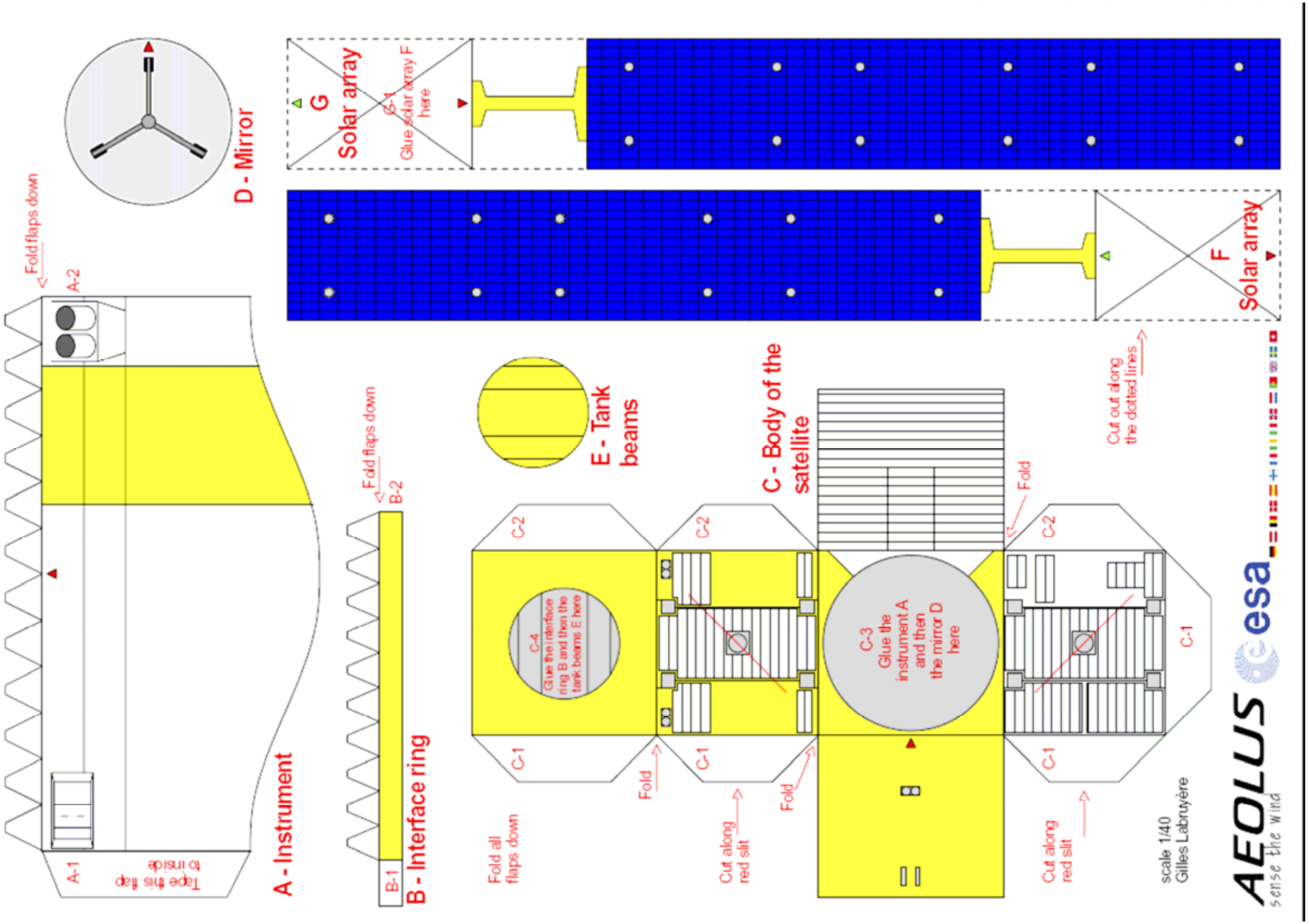
The satellite is designed for simple operation (7 day autonomy, 5 day unattended survival), repeating 7-day command cycles.

Aeolus satellite



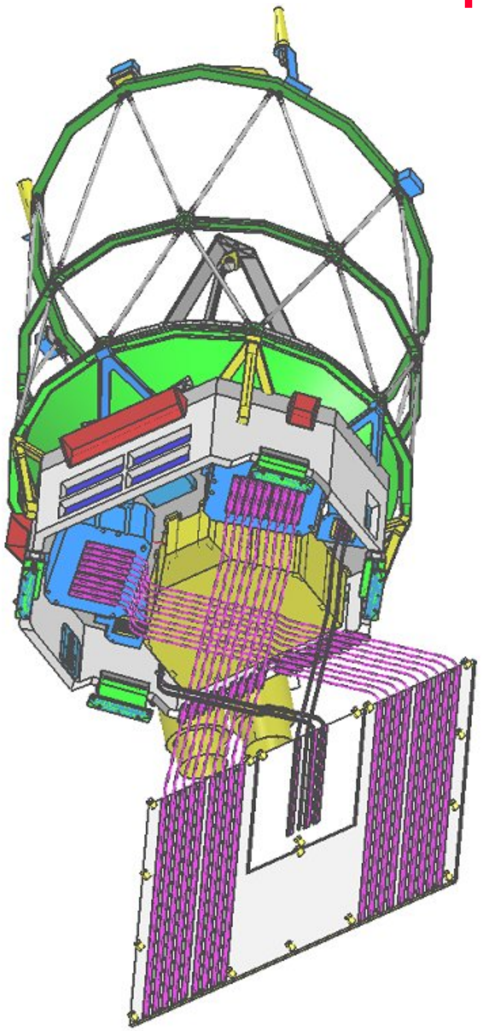
Artist's view showing the location of most satellite and ALADIN subsystems

Build your own Aeolus



ALADIN

Atmospheric Laser Doppler Instrument



ALADIN is the only payload of Aeolus. Its size is dominated by the large afocal telescope of 1.5 m diameter.

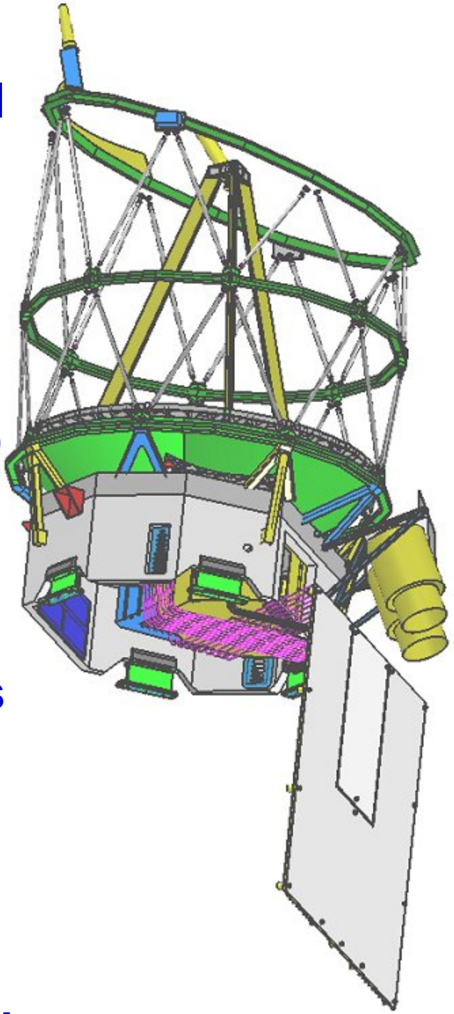
It uses diode pumped Nd:YAG laser to generate UV-light pulses (355 nm) emitted to the atmosphere.

Two transmitter laser assemblies (blue) and the receiver (yellow) are on the structure below the telescope.

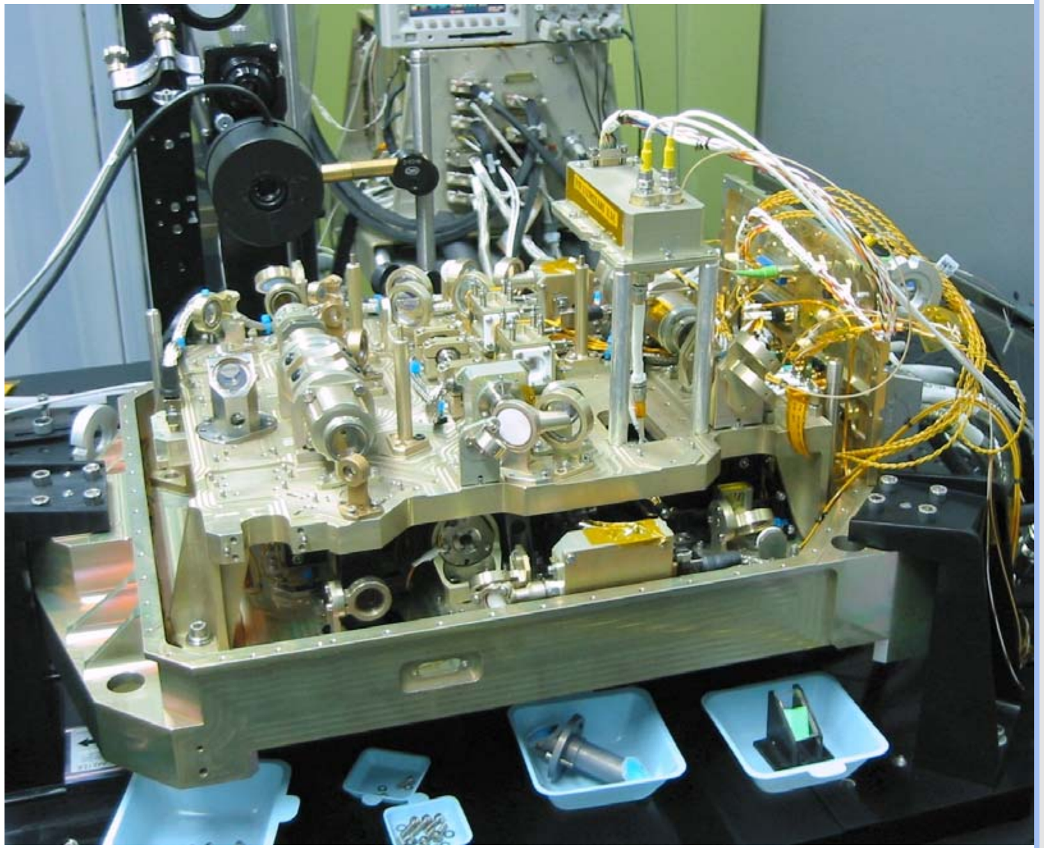
A large radiator (mounted on the satellite bus) is coupled with heat pipes to the transmitter lasers.

Star trackers are mounted on ALADIN structure to give best possible pointing reference.

Total mass is 470 kg, 830 W power need (average).



ALADIN transmitter laser (TXA)



A diode pumped Nd:YAG laser is generating single frequency pulses at 355 nm wavelength with 150 mJ energy at 100 Hz repetition rate.

It is operated in burst mode of 12 s on (5 s warm up, 7 s measurement), and 16 s off to increase life time and reduce power consumption.

For single mode operation, the laser is injection seeded with output from a cw MISER laser in the Reference Laser Head (RLH) which is coupled via single-mode fibres to the power laser head.

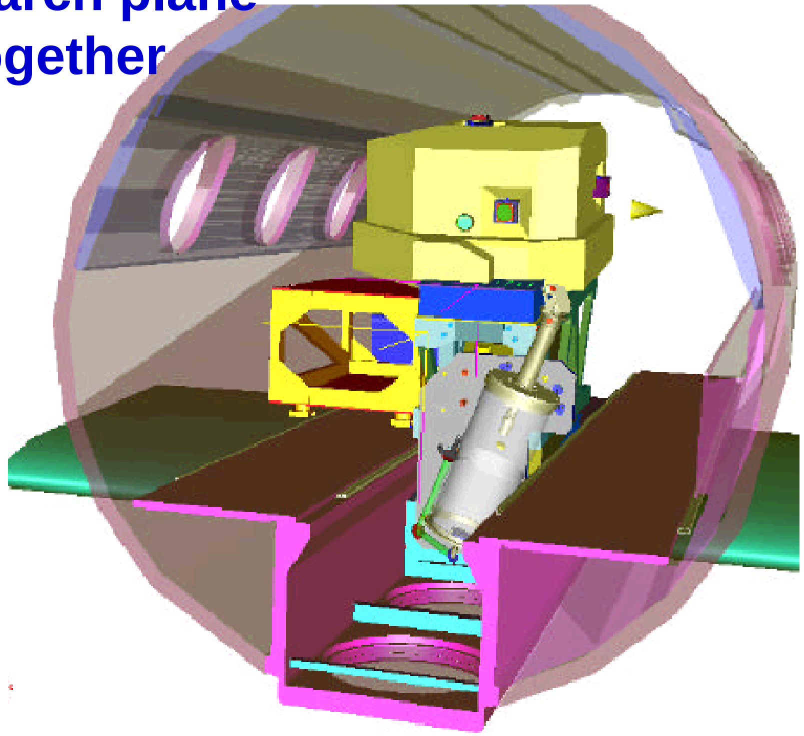
The laser is conductively cooled via heat pipes mounted on thermal interface plates.

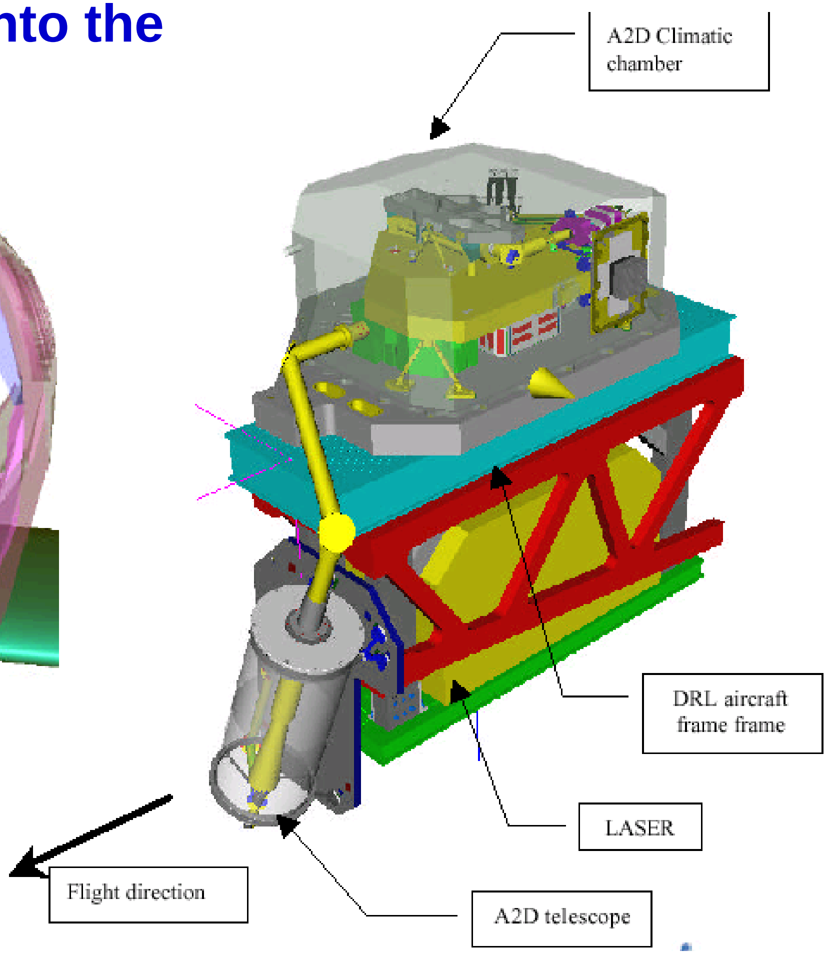
...and the complete Aeolus satellite

Aeolus Structure Model in ESTEC, June 2005

ALADIN Airborne Demonstrator A2D

The pre-development model of the receiver and one of the breaqdboard lasers have been combined to a complete wind lidar to fit into the Falcon research plane from DLR together with the CTI 2-um wind lidar





…and the A2D in D-CMET

A2D during acceptance testing after installation in D-CMET on for first proof flight 18 Oct 2005

Aeolus will be first spaceborne wind lidar

First space mission to measure global wind profiles

Mie and Rayleigh receivers allow to measure wind profiles up to 30 km

Aeolus should evolve into operational wind profilers a series of dedicated wind satellite in dusk-dawn orbit would fulfill the demands on global data coverage

All systems are in manufacturing phase