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Aladin performance validation

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Aladin performance validation

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Aeolus: ESA's Wind Lidar Mission

Scientific objectives

- To improve the quality of weather forecasts;
- To advance our understanding of atmospheric dynamics and climate processes;

Explorer objectives

- Demonstrate space-based Doppler Wind LIDARs potential for operational use.

Observation means:

- Provide global measurements of horizontal wind profiles in the troposphere and lower stratosphere

Payload

- ALADIN: Atmospheric LAsEr Doppler INstrument

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in UV (80 mJ, 50 pulse/s) at a controlled frequency

Recalls

Aladin is a Doppler wind Lidar based on direct detection (no heterodyne function)

Aladin is self calibrated

- Emitted frequency measured at emission
- Absolute zero measured on ground echo
- Response independent from received amplitude
- Response slope calibrated in orbit

The receiver is closed during the laser emission in order to protect the receiver against straylight

The high energy laser sections are pressurised at ca. 0.6 mbar but the other units are operated in vacuum

The receiver is based on Fabry-Perot (Rayleigh) or Fizeau (Mie) interferometers

Aladin measurement principle
Power: 900 W
Mass: 500 kg

Step 1: Laser emission
Step 2: Emission towards atmosphere
Step 3: Backscattering from atmosphere: particle (Mie) at low altitude and molecules (Rayleigh) at higher altitude
Step 4: Optical and Detection analogue processing
Step 5: Calibrations and corrections

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Measurement principle

Doppler shift of backscattered light vs laser pulse

Aerosols signal (Mie)

- Fringe imaging technique
- The frequency drift is proportional with fringe position

Molecular signal (Rayleigh)

- Ecartometric measurement: two high resolution filters are placed on the aisles of the Rayleigh spectrum
- Two optical signals are measured: A and B
- Response is defined as:

$$R = \frac{A - B}{A + B}$$

Intensity

Wavelength

Laser Pulse 30 MHz

Mie Signal < 90 MHz

Rayleigh Signal 3340 MHz

Doppler shift < 350 MHz

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Overall architecture

ALADIN (Atmospheric **LA**ser **Doppler** **IN**strument) will be the first European space-borne Lidar and the first space-borne Doppler Lidar in the world. It is developed by Airbus D&S for ESA.

The ALADIN instrument is made of four main sub-assemblies: the opto-mechanical assembly essentially made of the structural parts the telescope and the thermal control H/W (also including components of the in-situ cleaning system and the Laser Cooling System), the optical bench assembly (OBA, including the sealed TRO), the lasers and finally the electrical units.

Redundant laser transmitters
Optical Bench Assembly (under cover)
Telescope baffle
Telescope
Lasers radiators

ALADIN:

- Direct detection Doppler Wind Lidar: Receiver based on HR interferometers (FWHM=50 fm)
- Mono-static concept -> transmit and receive beams propagate through the same path/telescope
- High energy UV laser -> typ. 80mJ @355nm
- Large telescope -> 1.5m diam.
- Overall mass ~500kg
- Power ~900W

Optical bench

Power Laser Head (PLH)
(internal accommodation)

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Development approach

Pre-development of the receiver and laser

Validation of the mechanical, thermal and optical model

Development and validation of the protoflight model

OSP-PDM
ESP-PDM
Performance test at ambient
Performance tests in thermal vacuum
Mechanical tests
Full performance Test with laser
Atmospheric tests
PDM & A2D Programme

Reference tests
mechanical tests on satellite STM
Reference tests
Performance tests in thermal vacuum
Final performance tests
OSTM Programme

OSP
ESP1,2 &3 (continuous mode)
OBA integration and tests (OBA-IT)
Global instrument integration (GII)
Instrument Full Performance (IFP)
Mechanical Support Programme (MSP)
at satellite level
Final full performance (FFP) in vacuum
Thermal vacuum performance tests
Mechanical tests
EMC performance tests (conducted)
We are here!
PFM Programme

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Performance test overview

Instrument performance tests are:

- Performed at ambient pressure
- Intended to validate the random error and a part of the systematic errors
- Intended to be a rehearsal of the performance test to be performed in vacuum

Main tests

	Radiometric and geometric	spectral
Low level test For characterisation and in-orbit performance consolidation	Peak transmission, noise in darkness, emitted energy, emission divergence, Rayleigh spot diameter	Mie channel resolution, fringe distortion
Higher level test Direct performance verification	Random error	Response calibration accuracy, response slope, residual error in response

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Test set-up overview

The configuration is

- Instrument Flight model, except laser cooling system which is replaced by a chiller
- Thermal GSE
- Mechanical GSE
- Electrical GSE
 - Power supply
 - Digital interface to/from the instrument
- Optical GSE
 - Generate a calibrated atmospheric Echo (frequency and amplitude)

All is set in an ISO5 clean room

Operation in darkness

Operator protection (eye safety)

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Random error: Rayleigh channel (2-20 km alt.)

Test results are better than the success criterion and in line with expected values

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Spectral tests

Test	Expected	Achieved	comment
Mie channel resolution	< 150 MHz	112 MHz	At FWHM on atmospheric path
Mie channel spectral range	>1550 MHz	1520 MHz	
Mie fringe distortion	< 25 MHz	+/-27 MHz

Mie channel fringe versus frequency drift (+/-340 MHz or +/- 100 m/s)

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Spectral response

	Expected	Achieved	comment
Mie channel/CAL	111 MHz/p	99 MHz/p	Difference may be due to a variation of the Fizeau wedge under gravity. Weak impact on performance
Mie Channel/ATM	110 MHz/p	99 MHz/p	
Rayleigh channel/CAL	2083 MHz/resp	2127 MHz/resp	
Rayleigh channel/ATM With Rayleigh spectrum	1694 MHz/resp	1666 MHz/resp	
Rayleigh channel/ATM With Mie spectrum	2083 MHz/resp	2173 MHz/resp

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First conclusions and next steps

**The measured performance is very close to the expected value.
Especially the random error (high level test) is close to the predictions.**

This test result allows the in-orbit performance to be consolidated (see graph: 1 m/s is 3.43 MHz)

The robustness of the UV coatings was tested over ca. 500 Mshots

Next steps:

- ✓ Integration of the instrument on the platform in Airbus D&S UK (done)
- Functional test at satellite level (up to December 2016)
- Satellite mechanical tests (Q1-2017)
- Satellite thermal vacuum tests (Q2-2017)

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