" Status of the ATLID Backscatter Lidar : System and Technology aspects "

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Abstract

The European Space agency (ESA) has carried out for some years activities to develop a backscatter lidar called ATLID. ATLID is now one instrument of the ESA Earth Radiation Mission (ERM) payload. Systems studies and technology developments of critical units have been performed. Presently, the technology effort is oriented towards the integration of the key subsystems (transmitter, receiver) and the system aspect will be reworked in the frame of the Phase-A of the ERM. The following presentation deals with the main results of the ATLID breadboarding activity, the ATLID requirements for the ERM and some system considerations (performance, budget, eyesafety, . . .).

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ATLID Technology Pre-Development Programme

(Matra Marconi Space, DSS-Dornier)

- Aim of Stage 1: (1992 → 1997)
  - Phase 1: Define a compact scanning lidar concept to be flown on an ENVISAT type platform
  - Phase 2: Raise the instrument technology maturity by breadboarding key 'critical' units.

Breadboarded Unit	Objective
Laser Head	efficiency, high power, thermal control, lifetime
Q-switch/Electronics	laser damage, EMC
Laser Power Supply	efficiency, EMC
Laser Head TC	large heat load, high temperature stability
Telescope	large diameter, low mass
Scan Mechanism	torque compensation, pointing accuracy, lifetime
Spectral filter	narrow-stable bandpass, transmission
Detection chain	very low noise operation

- Aim of Stage 2: (1998 → ..)
  - Assemble the breadboarded units to build/test Functional Verification Models of the transmitter and receiver.

Reference: D. Morancais (1994), " The compact version of the Atmospheric Lidar Instrument (ATLID)", SPIE Vol. 2310.

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ATLID Laser Transmitter Breadboard

(Alenia-Difesa & Quantel)

- Actively Q-Switched Diode Pumped Nd-YAG zig-zag Slab Laser (1064 nm)
- Performances

Laser Parameters	Measured values	Comments
Energy/ Duration	100 mJ/ 18 ns	Pulse to Pulse Energy stability 1.5%
PRF	100 Hz	10 W Optical output
Beam mode	$M^2_H \approx 1.0$ $M^2_V \approx 1.5$	H = ∥ to zig-zag plane V= ⊥ to zig-zag plane
Beam angular stability	< 50 μrad(H)	on a 4 mm (H) x 3 mm (V) beam
Linewidth/ wavelength Stability	< 0.6 Å / 0.04Å	over 20°C-32°C
Wall-plug efficiency	6.3 %	BOL & Commercial Laser Diodes

Reference: E. Armandillo et al., (1997),"Diode-pumped high-efficiency high-brighness Q-switched Nd:Yag slab laser, Optics Letters, Vol.22, No.15, pp. 1168-1170.

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ATLID Spectral Filter Breadboard

(DSS, Tecoptics)

- Fixed Fabry-Perot etalon plus a blocking filter to select one etalon order
- Performances

Parameters	Measured values	Comments
Center wavelength	1064.15 nm in vacuum	matched to laser emission line in vacuum
Peak transmission	63%	including blocking filter
Filter FWHM	0.2 nm	larger than laser line FWHM
Filter equivalent bandwidth	0.3 nm	parasitic humps of transmission over APD spectral response
FOV	± 5.3 mrad	account for return beam divergence & misalignment
Stability Δλ/ΔT	-0.003 nm/K	Require temperature control ± 3K to achieve ± 0.01 nm peak wavelength stability

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ATLID Detection chain Breadboard

(Matra Marconi Space, EG&G, TNO)

- Analog detection chain composed of a Front-End Assembly Hybrid (0.8 mm Si-APD, 35 % Q.E., Thermoelectric cooler, Transimpedance Amplifier), a Proximity electronics providing coarse offset compensation and Detection electronics featuring two parallel analog processing chains (High bandwidth & Low bandwidth).

- Performances

Parameters	Measured values	Comments
Dynamic Range	0.1 pW- 2 nW	Low value: aerosol return High value: Ground return + high background
RDC Signal Linearity	1.2 % over 12 bits	
Gain stability	0.3 %	over 1 hour
RDC Electrical Bandwidth Sampling frequency	1 MHz 4 MHz	50 m ranging resolution
SNR (Daytime- thin cirrus over dense cloud)	2	Useful signal = 60 pW Background signal = 230 pW
SNR (Nightime- dense cumulus)	15	Useful signal = 620 pW Background signal = 0 pW

Reference: D.Gheri et al., (1997), "ATLID detection chain Breadboard", SPIE vol. 2956.

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ATLID on The Earth Explorer Earth Radiation Mission

- The ERM platform should embark 4 instruments on a 410 km altitude SSO orbit (2:00-14:00):

  - a Broadband Radiometer,
  - a Visible-Infrared Imager,
  - a Cloud Profiling Radar (CPR),
  - a non-scanning Backscatter Lidar (ATLID).

- ATLID main performance requirements

Parameters	Values	Comments
Laser wavelength	1064 nm	eyesafety drives the laser divergence and IFOV
Pointing	Nadir	Synergistic operation with the CPR
Vertical localisation error	< 100 m	0-25 km observation altitude range
Signal to Noise Ratio	> 3 > 8	single shot, all clouds except reference thin Cloud* averaged over 10 km & at bottom of reference thin Cloud*
Calibration Constant	< 10 %	⇒ lidar calibration procedure and/or radiometric stability

* Reference thin cirrus cloud ($\beta = 1.4\ 10^{-5}\ m^{-1}.sr^{-1}$; $\sigma = 2\ 10^{-4}\ m^{-1}$; $\Delta H = 1000$ m) above a thick cloud.

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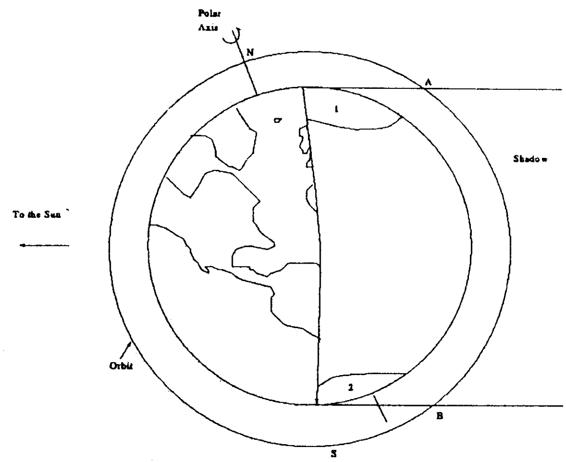
ATLID Eyesafety issue

■ Population at Risk

- Amateur astronomer looking at Zenith (best observation condition) with a naked eye behind a telescope of large aperture (telescope of aperture as large as 150 mm are commercially available at cheap price),

- SSO Satellites are visible in mid-latitude summer (region 1) and can be easily tracked.

■ For ATLID 100 mJ laser divergence design, a 150 mm aperture telescope is tentatively considered for eyesafety issue (~ 100 m footprint). A "serious" risk analysis will be needed to freeze this value.



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ATLID tentative characteristics on the ERM

Mission		Receiver (Rx)	
Orbit	SSO 2:00-14:00	Optical efficiency (Tx+Rx)	0.40
Altitude	~ 410 km	Filter equivalent bandwidth	0.3 nm
Transmitter (Tx)		IFOV	560 μrad
Laser	LD pumped Nd:YAG	Detection chain	APD (analog mode)
Wavelength	1064 nm	Electrical Bandwidth	~ 1 MHz
Pulse Energy	100 mJ	Sampling rate	~ 4 MHz
PRF	20 Hz	Budgets	
Tx Divergence	230 μrad	Power	190 W EOL
Telescope		Mass	210 kg
Diameter	60 cm	Data rate	170 kbits/sec

Eyesafety w.r.t 150 mm aperture telescope