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ELISE: NASDA Spaceborne Lidar

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Introduction

ELISE(Experimental Lidar In Space Equipment) is a two-wavelength spaceborne backscatter lidar and will be loaded onto the Mission Demonstration test Satellite 2 (MDS-2) which will be flown into sun-synchronous orbit (altitude: 550km) in 2002.

ELISE is designed for both engineering scientific purposes. For engineering purposes, ELISE will establish the key technologies such as a Laser Diode (LD)-pumped high-power laser and a high-efficiency detector (i.e. Silicon Avalanche Photo Diode (Si-APD)), which are required for future spaceborne lidars. For scientific purposes, ELISE will observe the global distributions of clouds (especially cirrus) and aerosols, and obtain information about multi-layered cloud structures. ELISE is expected to observe and obtain these data over course of year. These observations are expected not only to demonstrate the capabilities of spaceborne lidar but also to be incorporated into future design.

The instrument

ELISE is a typical backscatter lidar system and is designed to make measurements of cirrus, aerosols and the atmospheric density with a signal to noise ratio over 10. A preliminary configuration of ELISE and a schematic diagram of ELISE are shown in Figs. 1 and 2. The main system parameters of ELISE are shown in Table 1. This instrument consists of seven major components: a laser transmitter, a transmission optics, a telescope, receiver optics and detectors, a signal processor, a thermal controller (including a radiator panel), and a power supply. The laser transmitter is a LD-pumped Q-switched Nd:YLF laser with KTP, and simultaneously produces output energy of 84 mJ (1053 nm) and 10 mJ (527 nm). The pulse repetition frequency is 100 Hz and the beam divergence is 0.17 mrad. ELISE has an alignment adjuster in the transmission optics in order to correct misalignment between the laser transmitter and the receiver. It has a Cassegrain telescope with the an 1 m primary mirror and about an 18 cm secondary mirror, each of which is made of Beryllium. The field of view is 0.22 mrad. A received backscattered light from targets is led to the receiver optics and separated by the dichroic mirror into two colors. A fundamental wavelength backscattered light is separated into 9-to-1 ratio by a beamsplitter and detected by two Si-APD detectors. One of the detectors operates in analog mode and the other operates in photon-counting mode. The analog Si-APD detector uses 90% of the received 1053 nm light for measuring clouds, and the photon counting mode Si-APD detector uses the rest of received 1053 nm light for measuring aerosols. A second harmonics is only detected by the photon-counting mode Si-APD detector. A schematic diagram of receiver optics of ELISE is shown in Fig.3.

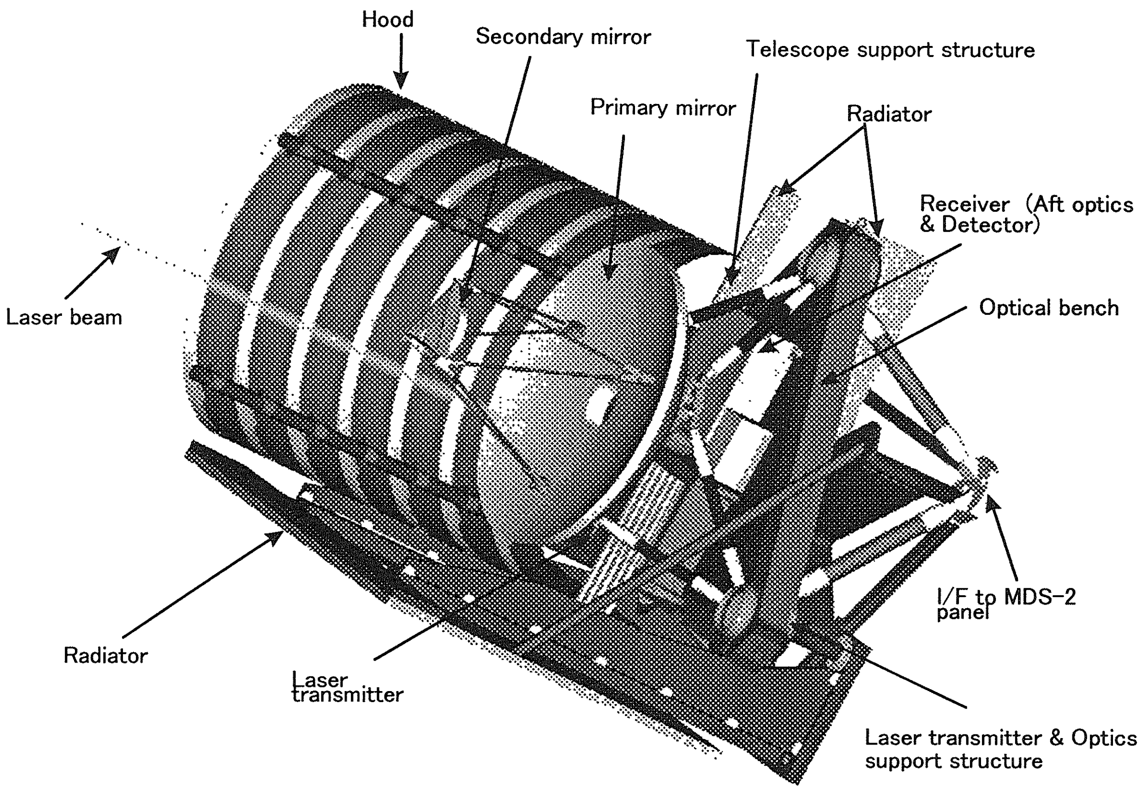

Fig. 1 Preliminary configuration of ELISE

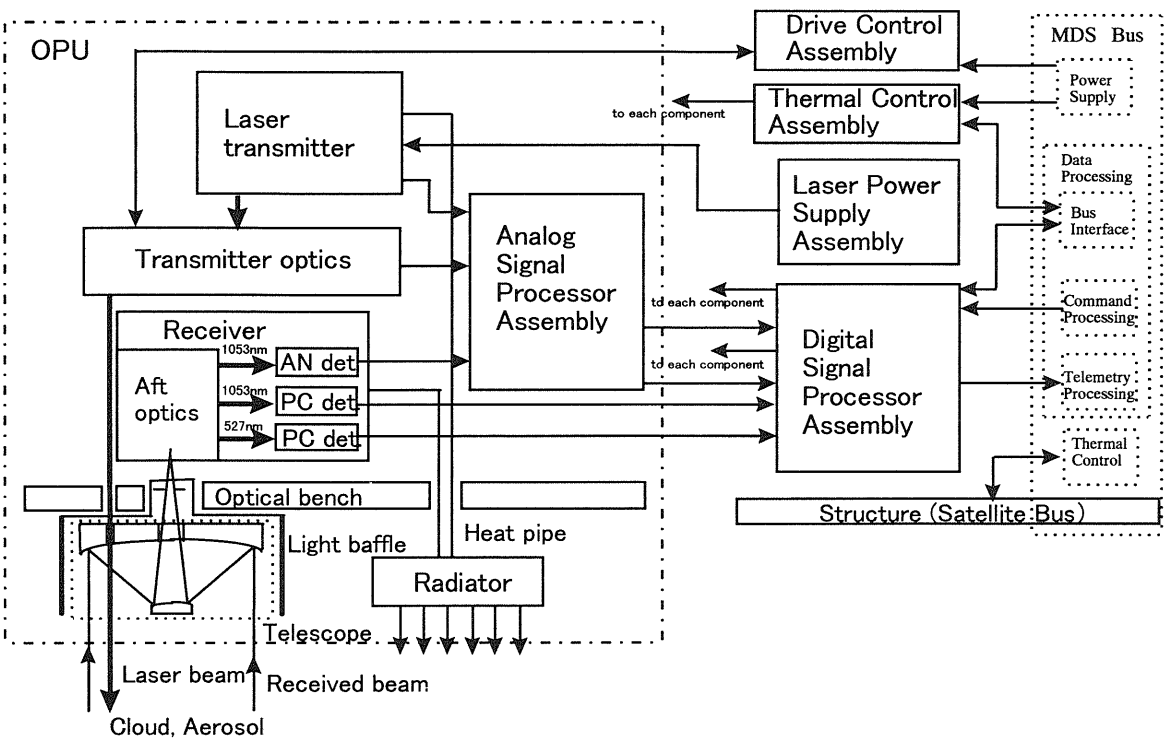

Fig. 2 ELISE system function diagram

Table 1　ELISE system parameters

Items		Analog detection	Photon Counting detection	
		Fundamental	Fundamental	SHG
Performance	Vertical resolution	100 m (667 nsec)		
	Horizontal resolution	1.4 km (Int. 20) 4.2 km (Int. 60)	1.4 km (Int. 20) 21 km (Int.300)	
	SNR	>10		
Transmitter	Laser	LD pumped Q-switched Nd:YLF laser + KTP		
	Wavelength	1053.2 nm		526.6 nm
	Output energy	84 mJ		10 mJ
	PRF	100 pps		
	Beam divergence	0.17 mrad		
Transmission Optics	Opt. Transmission	90%		
Receiver	Telescope diameter	1 m		
	Field of view	0.22 mrad		
	Filter band width	0.3 nm	4 nm	
	Opt. Transmission	40 %	6.5 %	60 %
	Quantum efficiency	31.5 %	———	———
	Det. Probability	———	1.25 %	34 %
	Dynamic range	50.6 dB	5 M counts/sec	
Mass		250 kg		
Power		390 W (maximum)		

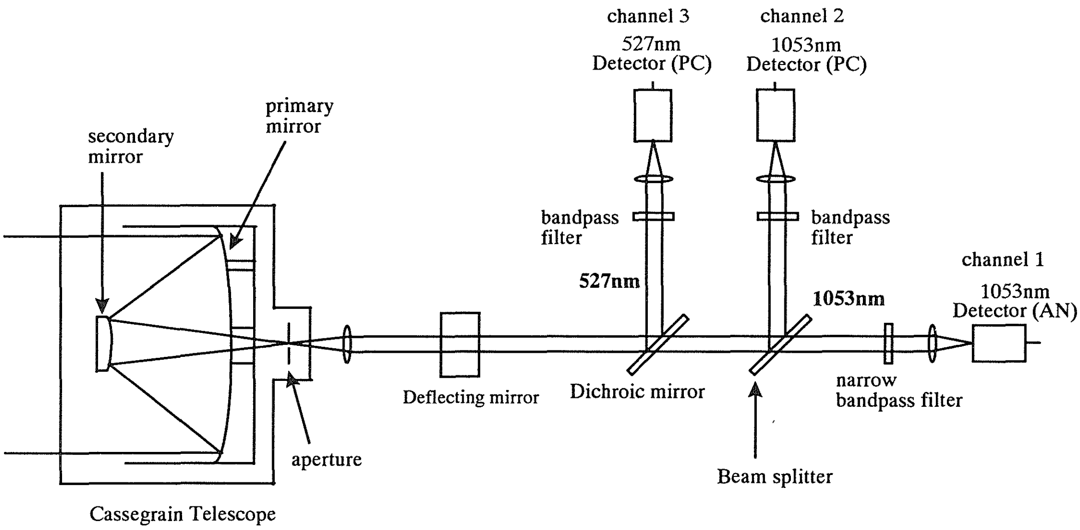

Fig. 3　Schematic diagram of receiver optics of ELISE

The operation mode of ELISE

ELISE has 6 operation modes in orbit: the observation modes 1, 2, and 3, the alignment mode, the stand-by mode and the safety mode. The safety mode is only used when an emergency occurs such as under voltage of a satellite bus and the alignment mode is only used when laser transmitter and receiver are misaligned. The number of data integration times can be changed in each observation modes. The details of each mode are shown in Table 2. Basically we are going to operate ELISE in observation mode 1a in dayside of earth and in observation mode 3d in nightside of earth. The example of a daily operation plan is shown in Fig. 4.

Table 2 Operation mode of ELISE

	ch1 1053 nm (AN)	ch2 1053 nm (PC)	ch3 527 nm (PC)	heater
observation mode 1a	ON (Int. 20)	OFF	OFF	ON
observation mode 1b	ON (Int. 60)	OFF	OFF	ON
observation mode 2a	OFF	ON (Int. 20)	ON (Int. 20)	ON
observation mode 2b	OFF	ON (Int. 300)	ON (Int. 300)	ON
observation mode 3a	ON(Int. 20)	ON(Int. 20)	ON(Int. 20)	ON
observation mode 3b	ON(Int. 20)	ON(Int. 300)	ON(Int. 300)	ON
observation mode 3c	ON(Int. 60)	ON(Int. 20)	ON(Int. 20)	ON
observation mode 3d	ON(Int. 60)	ON(Int. 300)	ON(Int. 300)	ON
alignment mode	OFF	OFF	ON	ON
stand-by mode	OFF	OFF	OFF	ON
safety mode	OFF	OFF	OFF	survival heater

* (Int. 20) means that data is integrated 20 times.

UT	operation	UT	operation	UT	operation	UT	operation
0	observation mode 1b	6	observation mode 1b	12	observation mode 1b	18	observation mode 1b
1		7		13		19	
2	observation mode 3d	8	observation mode 3d	14	observation mode 3d	20	observation mode 3d
3	observation mode 1b	9	observation mode 1b	15	observation mode 1b	21	observation mode 1b
4		10		16		22	
5	observation mode 3d	11	observation mode 3d	17	observation mode 3d	23	observation mode 3d

Fig. 4 An example of a daily operation plan

Current status and schedule

In 1997 we began the preliminary design of ELISE and in March 1999 we started the detail design. The laser transmitter and the high-efficiency detector have been produced experimentally and will be finished by November of this year. The development of the flight model, which is called the Demonstration Model (DM) of ELISE will be finished by 2001. After the integration and test of MDS-2, ELISE will be launched in 2002.