Overview of NASDA MDS-LIDAR Program

N. Tanioka

(National Space Development Agency of Japan)

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Noritaka Tanioka, Yasuji Yamamoto, Tadashi Imai
National Space Development Agency of Japan (NASDA)
2-1-1 Sengen, Tsukuba-shi, Ibaraki-ken, 305 JAPAN

1. Concept of program

The LIDAR on Mission Demonstration Satellite (denoted as MDS-LIDAR) means two-wavelength backscatter lidar. It is planned to be launched on MDS-2 early in 2001. The MDS-LIDAR, which is now called ELISE (Experimental Lidar in Space Equipment), is one of NASDA's lidar programs. One of the special features of ELISE is to be developed in short period using two models called BTM (Basic Test Model) and DM (Demonstration Model). Through this program, we try to demonstrate the new spaceborne Lidar on earth observation satellites in future. The basic technology for spaceborne lidar like LD-pumped LASER, large diameter mirror and photon counting Si-APD(Silicon Avalanche Photo Diode) will be demonstrated and the data of basic technology in space environment will be obtained. ELISE will further observe the clouds in the high altitude (mainly cirrus), multi-layered clouds and aerosols. This observation will reveal the scientific meaning and availability of the data obtained by spaceborne lidar.

2. Tentative information about MDS-2

The aim of MDS is faster and cheaper development and the demonstration for technical challenging mission. It is now planned two MDS, and MDS-2 is assigned to ELISE. MDS-2 is planned to be launched by H-ⅡA together with Data Relay Test Satellite(DRTS) early in 2001. The orbit of MDS-2 is circular(non-sun synchronous), the altitude of orbit is about 550km, the inclination is about 30 degree, the orbital period is about 96 minutes. The tentative outline of the MDS-2 is shown in table 1.

Table 1. The tentative outline of the MDS-2

Dimension	approx. 1.1×1.2×H1.7
Weight / Power	650kg / 1.2kW (EOL)
- Bus	440kg / 950W
Attitude Control	
- method	zero-momentum 3 axed control
- accuracy	±0.14deg (3σ)
Data Downlink	1Mcps (real time + Data Recorder data)
Capacity of Data Recorder	TBD

3. Outline of ELISE

ELISE consists of 6 sub-systems. The main performance of ELISE is shown in table 2 and details of each sub-systems are described in other paper " Development of NASDA MDS-LIDAR" in this proceeding.

Table 2. The outline of ELISE

Weight / Power	210kg / 250W
LASER	LD-pumped Nd-YLF LASER with KTP
-wavelength	1053nm / 527nm
-laser power	90mJ / 4.4mJ
-pulse repetition frequency	100Hz
Receiver	1m diameter primary mirror and Si-APD detector

ELISE is expected to observe clouds and aerosols from 0 to 35km altitude with vertical resolution 100m and horizontal resolution 1.5km . The signal to noise ratio(S/N) of obtained data will be over 10. ELISE will observe clouds in all day but observe aerosols in nighttime only because signals backscattered from aerosols are much weaker than background light in daytime.

The orbit of ELISE is described in last section. Now the data obtained by ELISE is planned to be directly transferred to the NASDA ground station, or recorded by data recorder(DR) and reproduced later (the capacity of DR is not defined). ELISE will not use data relay satellite for data transmission. The ground station will be able to receive the data for 4 times a day and the period to receive the data will be about 6 minutes once time. One of 4 times will be used for ranging(measuring orbit) and the rest will be used for data transmission. ELISE is going to use S-band transmission that can transmit 1Mbits per second to ground, so, the amount of transmitted data per day will be about 1Gbits.

4. The Schedule of development of ELISE

As described in this paper, ELISE is to be developed in short period using two models called BTM and DM. The trial product of BTM is now started and will be finished by end of July 1998. The production of DM will be started in July 1998 and finished by end of 1999.

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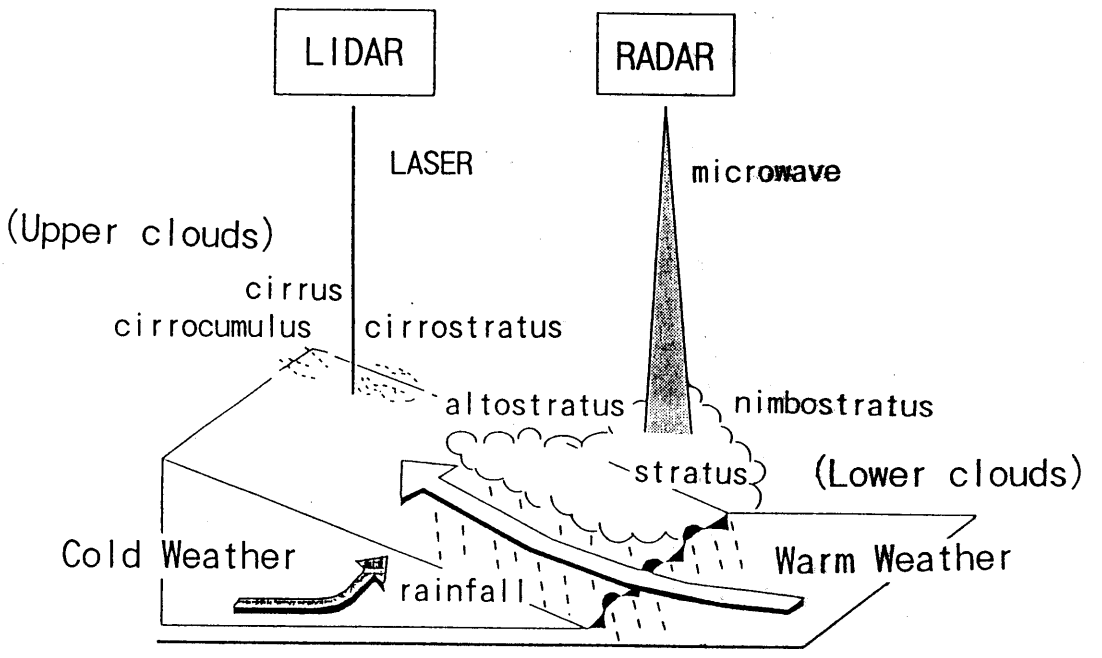
Dec/17/1996

Noritaka TANIOKA
Remote Sensing Technology Laboratory
National Space Development Agency of Japan (NASDA)

Introduction

- ELISE (Experimental Lidar In Space Equipment) is spaceborne backscatter LIDAR
- ELISE will be launched in early 2001 as one step of LIDAR research program
- The purpose of this equipment
  - Technological demonstration for future operational satellite
  - Experimental observation to demonstrate the availability of the data and scientific value.



LIDAR : Light Detection And Ranging

Current Status

- Arranging as program by Space Activities Commission in JAPAN (SAC)
- Requesting the 1997's ELISE budget
- Start the design of basic test model (research model) from the end of this year
- Trial productions and tests of critical components finished
- Experiment of ground based LIDAR is under going
- 1st. Experiment of airborne LIDAR finished in Oct. 1996

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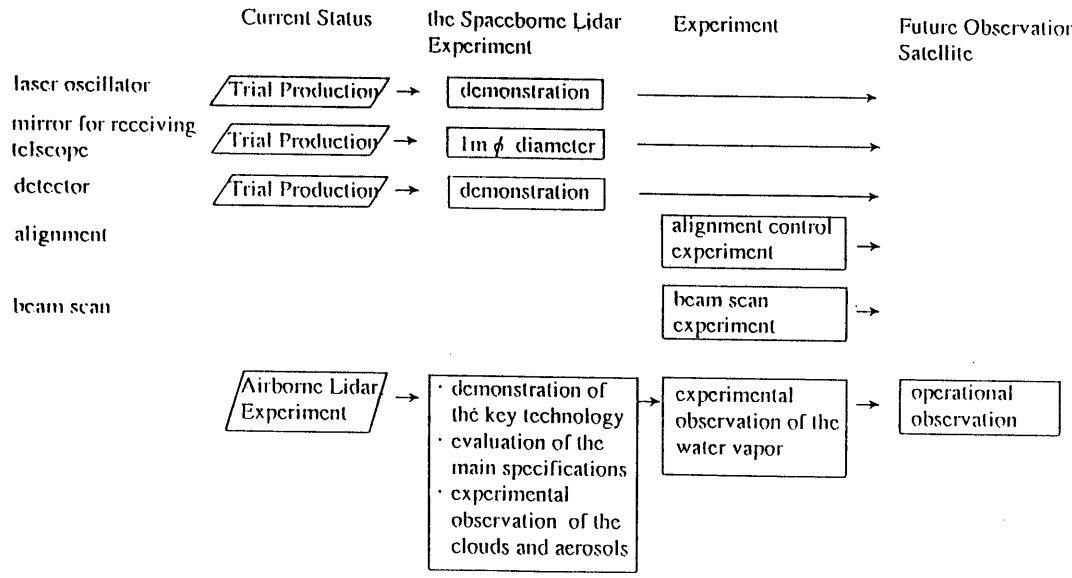
Lidar development scenario



Concept of ELISE program

- Demonstration of Critical components
  - laser oscillator, mirror, detector and thermal design
- Short term development
  - Two step development
    Basic Test Model(BTM) & Demonstration Model(DM)
- Single mission on Mission Demonstration Satellite(MDS)
- Experimental observation for scientific research
- One year mission

Mission 1 - Technological Demonstration

- System analysis
  - laser power, repetition frequency, beam divergence
  - evaluate the system performance
- System design
  - thermal design, mechanical design
  - evaluate the distortion and misalignment
- Basic technology of the critical components
  - laser oscillator, large diameter mirror, Photon Counting APD
  - acquisition of technological data under space environment

Mission 2 - Experimental Observation

- Demonstrate the availability of the LIDAR data & evaluate the scientific value
  - High altitude clouds (cirrus)
    - Research of climate processes
  - Multiply layered clouds
  - Aerosols
    - Tracer for stratospheric circulation and material transport.

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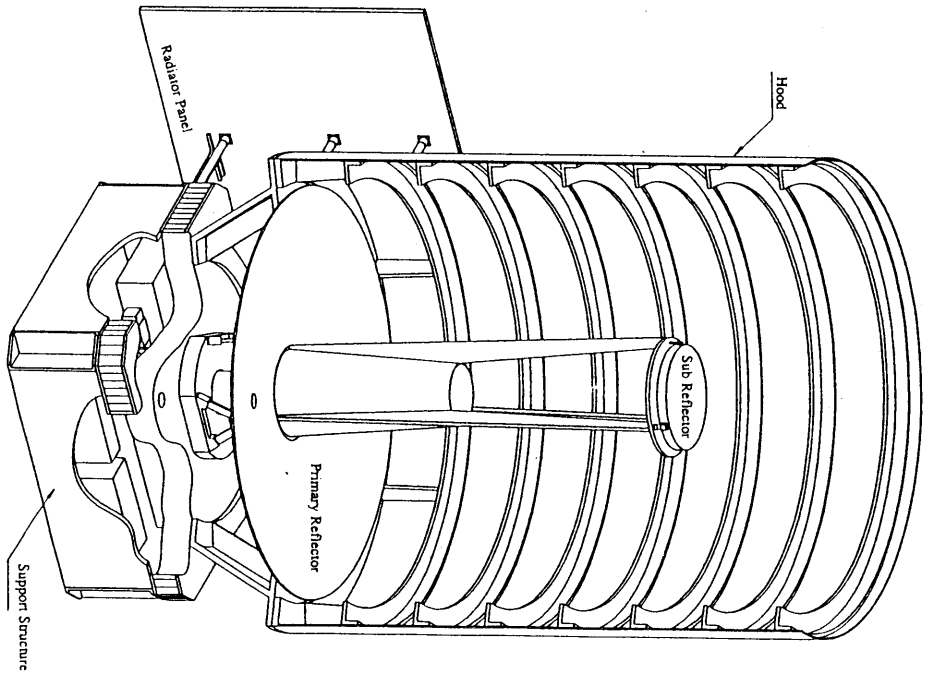
Conceptual Figure



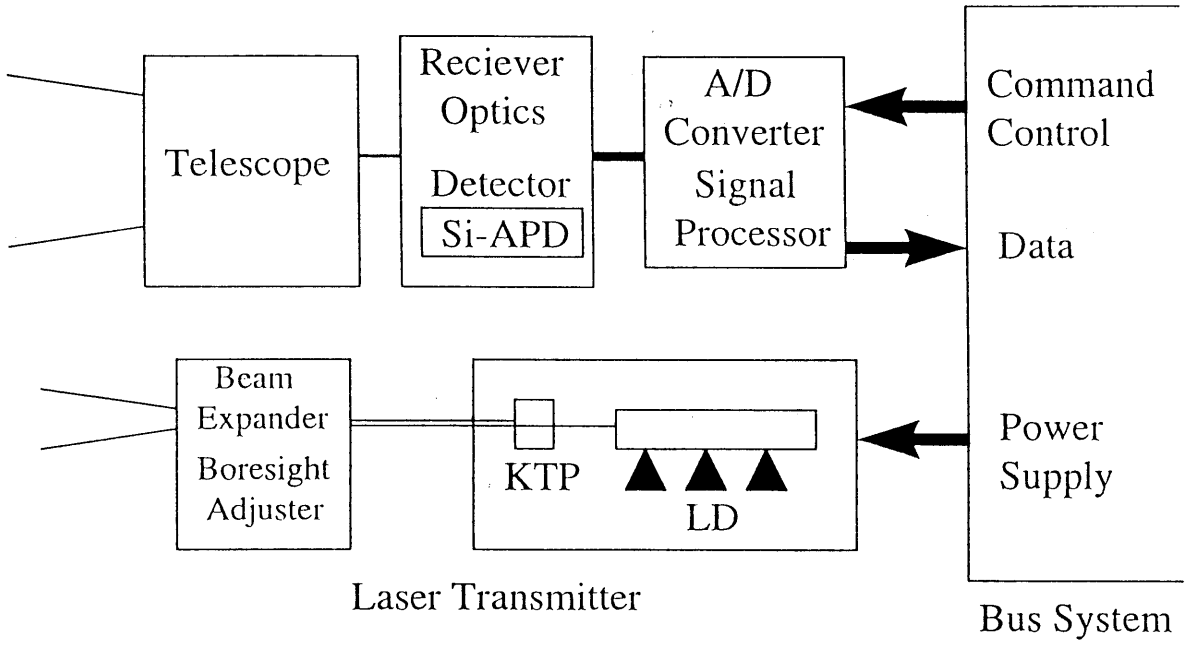


Fig. MDS - LIDAR Schematic Diagram

Outline of ELISE

- Observation
  - clouds, aerosols
  - 0-35km in altitude
  - 100m in vertical spatial resolution
  - 1.5km in horizontal spatial resolution
  - S/N > 10
- Mission life of 1 year
- Satellite orbit
  - circular, non-sun synchronous
  - altitude about 550 km
  - inclination about 30 degrees

Outline of ELISE (cont.)

- Resource
  - weight 210 kg
  - power 250 W
- Transmitter
  - laser-diode-pumped Nd:YLF and KTP
  - wavelength 1053 / 527 nm
  - laser power 90mJ / 4mJ
  - pulse repetition frequency 100 Hz
- Receiver
  - cassegrain telescope with ϕ 1m Be mirror
  - interference filter with a bandwidth of 0.3nm and 10nm
  - Si-APD photon counting module and analogue module

Observation Mode

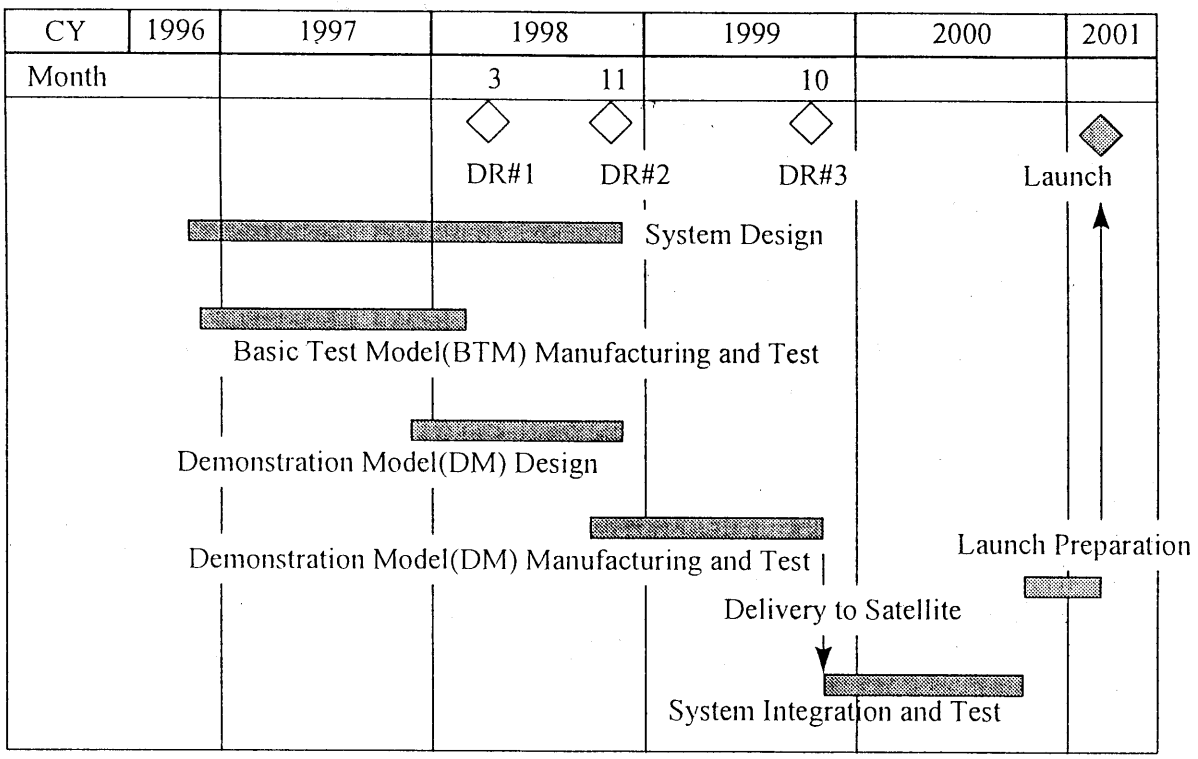
- Daylight observation mode
  (1) 1053 nm / analogue
- Night observation mode
  (1) 1053 nm / analogue (2) 1053 nm / photon counting
  (3) 527 nm / photon counting

wavelength	nm	1053	1053	527
detector mode		Analog	Photon Count.	Photon Count.
filter bandwidth	nm	0.3	10	10
Hor. spatial resolution	km	1.5	TBD	TBD
Ver. spatial resolution	Km	0.1	1	1
S/N		>10	TBD	>10

Operation

- about 15 revolutions per day
  - NASDA's station can receive the data for 4 path over the region near Japan
    - 1 path for ranging (orbit measurement)
    - 3 path for data transmission
- S-band transmission has 1 Mbps capability
- Data transmission will be made by direct transmission for ground station. Data relay satellite not used.
- Data recorder will be installed (TBD)
- Distribution for scientific analyst with / without bilateral agreement (TBD)

Schedule



Field Activity

- Ground Based LIDAR Experiment
  - Manufactured by NEC's Fuchu Plant
  - Observation at NASDA Tsukuba Space Center

- Airborne LIDAR Experiment
  - Beachcraft B-200 installed model
  - Manufactured by MELCO's Kamakura Plant
  - Observation at Tottori Sandhill and over the sea

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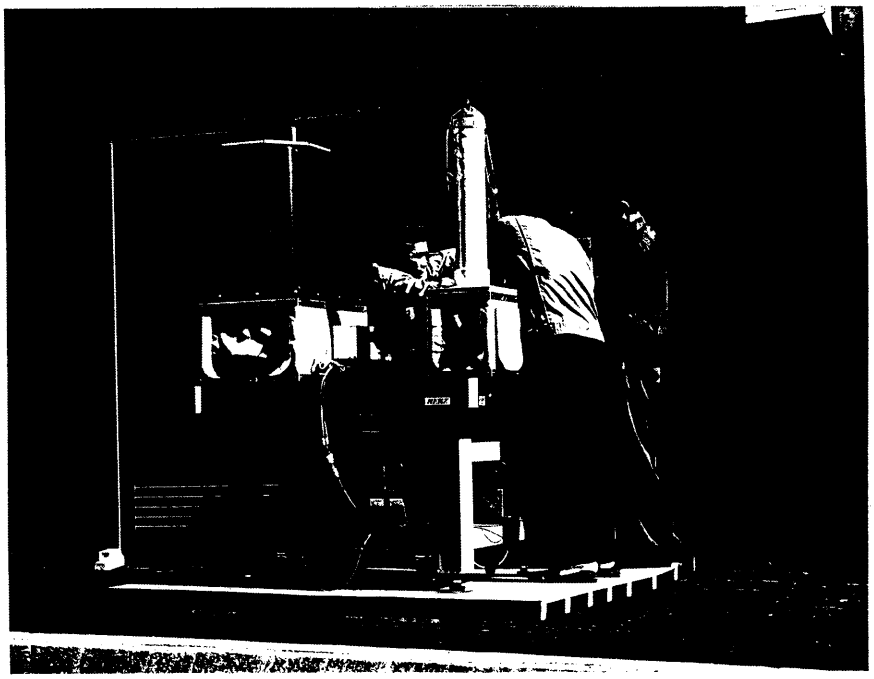
Experiment of Ground based LIDAR



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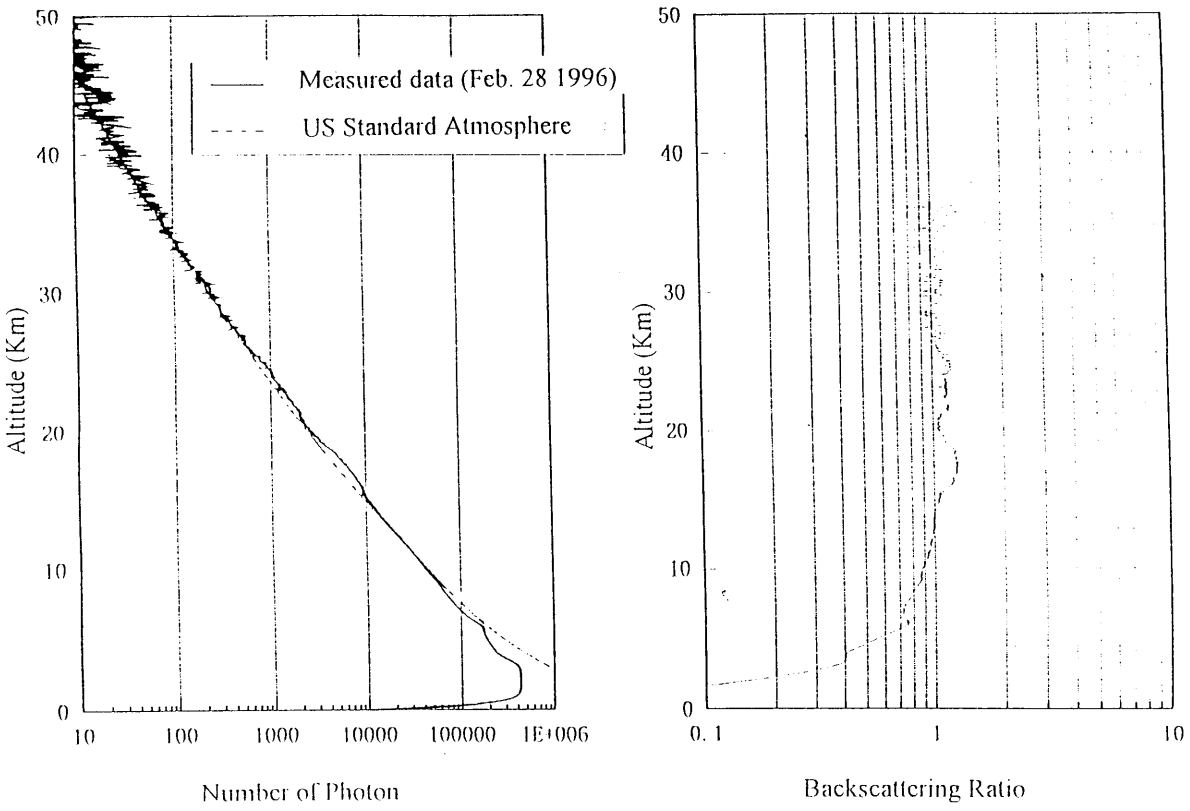

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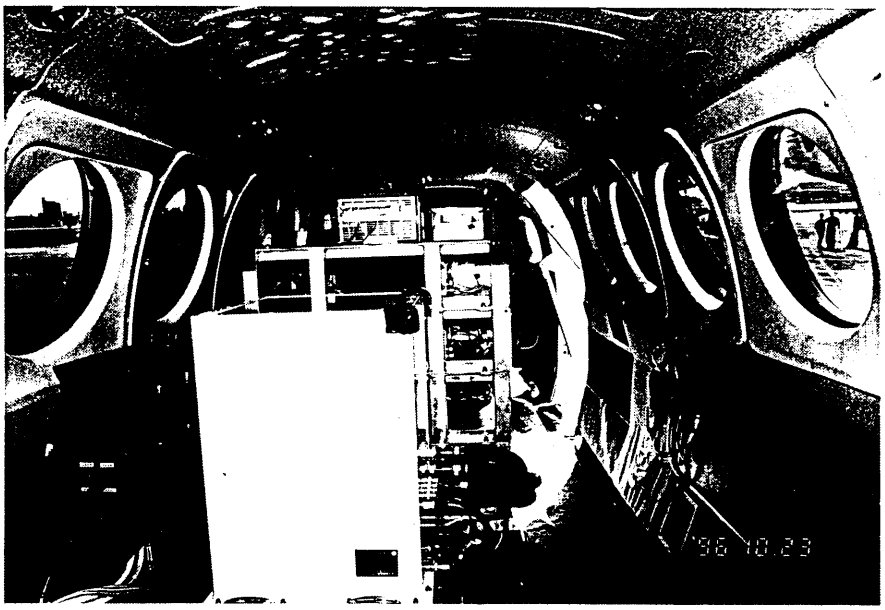
Experiment of airborne LIDAR



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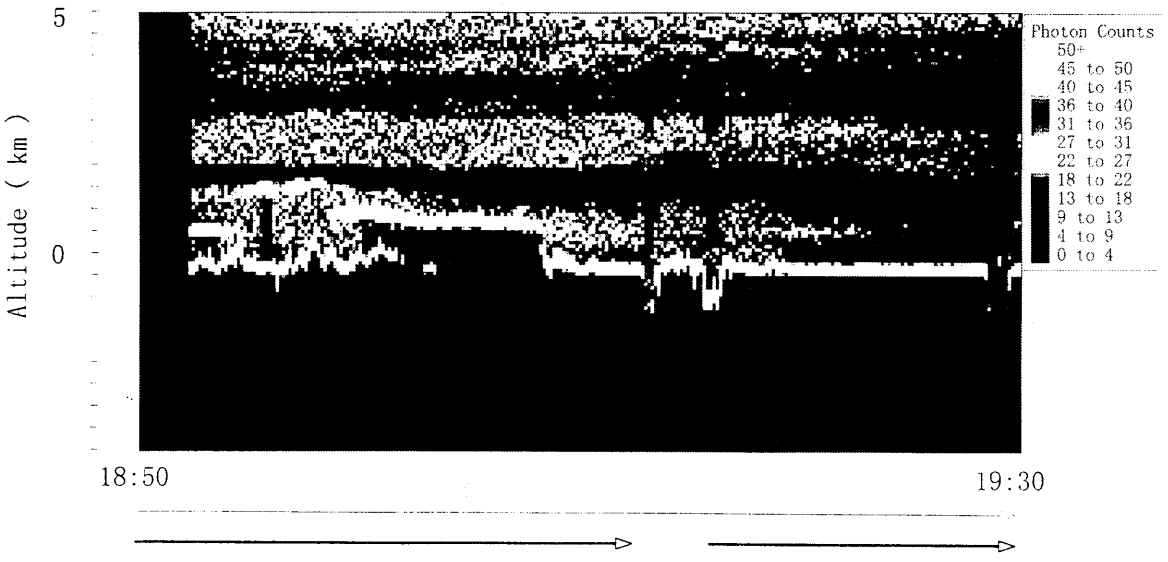
Airborne Lidar Observation (PhotonCounting Method)

Object : clouds, aerosol
Date : 1996/10/22



Concept of MDS

- Ground rule of MDS
  - MDS is Mission Demonstration Satellite
  - MDS is categorized into technical challenge mission
  - MDS will be installed single mission
  - Cheaper & faster development

Information of MDS-2 (tentative)

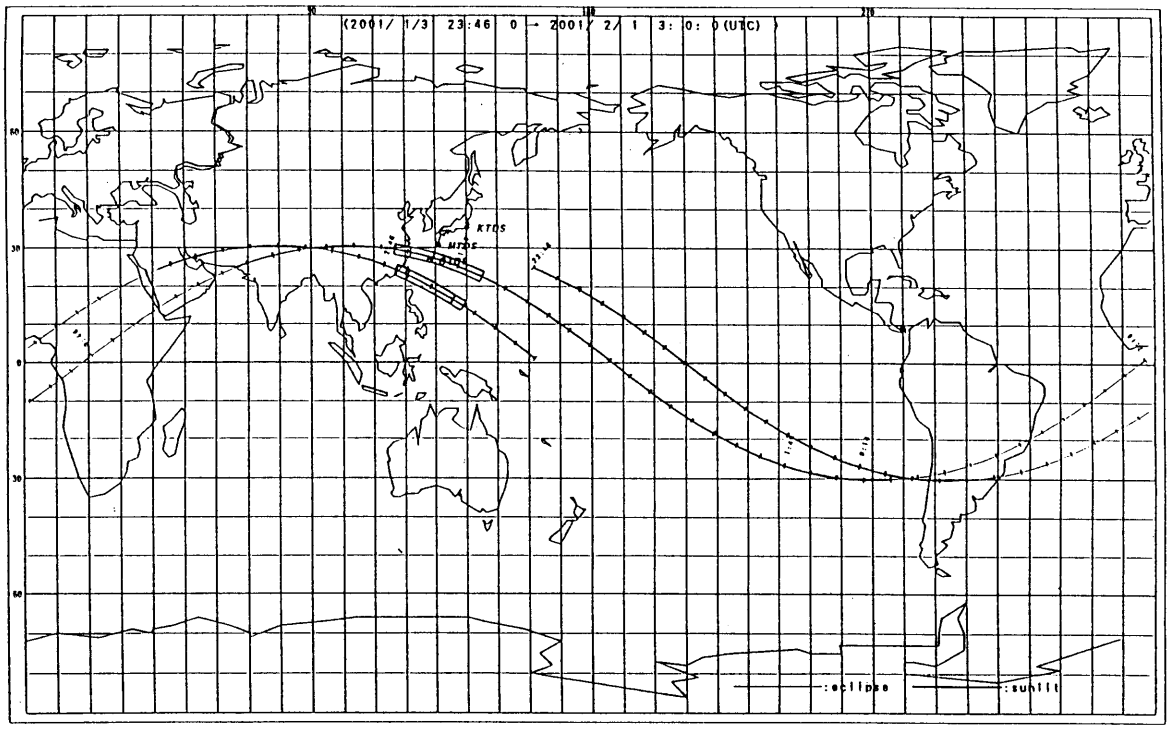
- MDS-2 assigned ELISE program
- Dual Launching with DRTS (Data Relay Test Satellite) by H-IIA launch vehicle
  - satellite orbit circular (non-sun synchronous)
  - initial altitude 300 Km
  - boost up altitude 550 Km
  - inclination 30 degree
  - Period 96 minutes

Characteristics of MDS-2 (tentative)

- Dimension — approx. 1.1 x 1.2 x H1.7 m
- Weight / Power — 650 kg / 1.2 KW (EOL)
  - mission — 210 kg / 250 W
  - bus — 440 kg / 950 W
- Attitude Control
  - method — zero-momentum 3-axes control
  - accuracy — ± 0.14 deg (3σ)
- Data downlink — 1Mbps (real time + DR data)
- Datarecorder capability — TBD

ELISE Data Transmission (tentative)

- Frequency — 2220MHz
- Modulation — BPSK
- Data format — TBD
- Data rate — 1,048 Kbps
- Downlink station — NASDA + α (TBD)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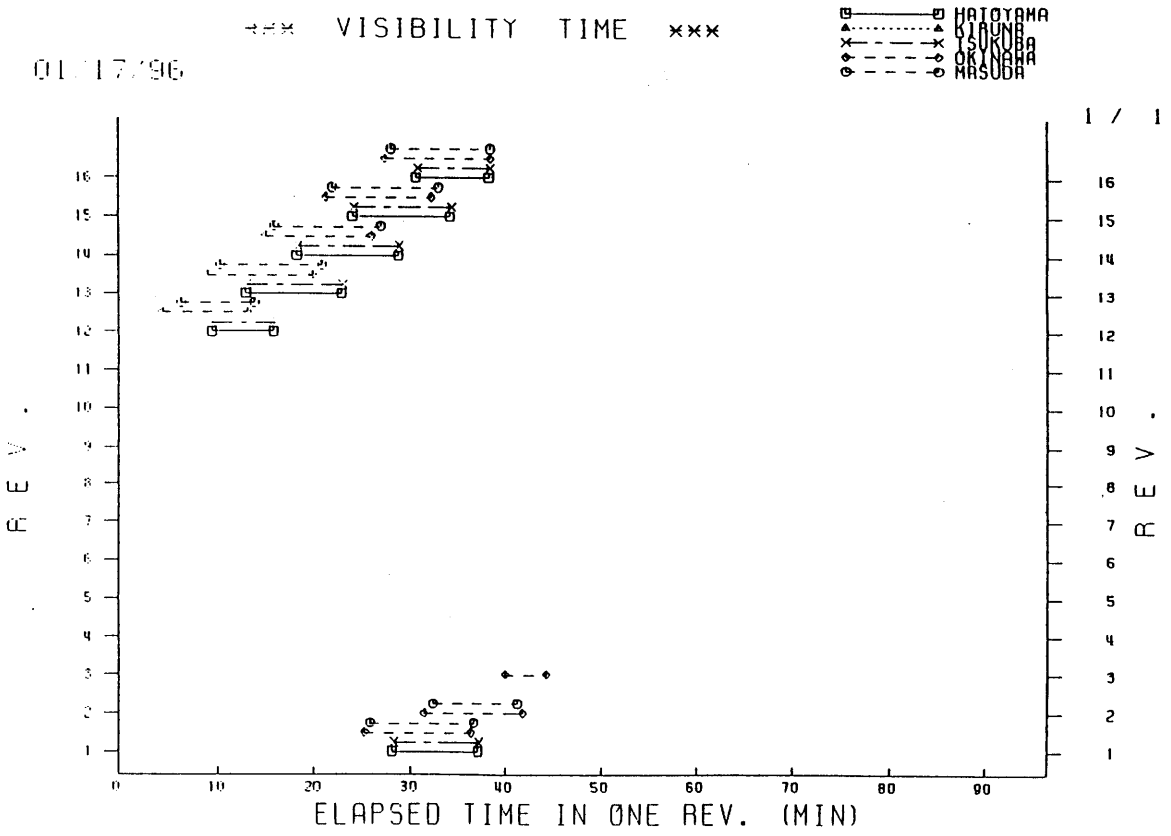
MTSF
:eclipse
:sunlit


VISIBILITY TIME
HAIOTAMA
KIAUNG
TSUKUBA
OKINAWA
MASUDA
1 / 1
REV.
ELAPSED TIME IN ONE REV. (MIN)

Candidates of ELISE / MDS-2