

# **A Satellite Tracking Demonstration On Ground Using a 100mm Class Aperture Optical Antenna for Space Laser Communication**

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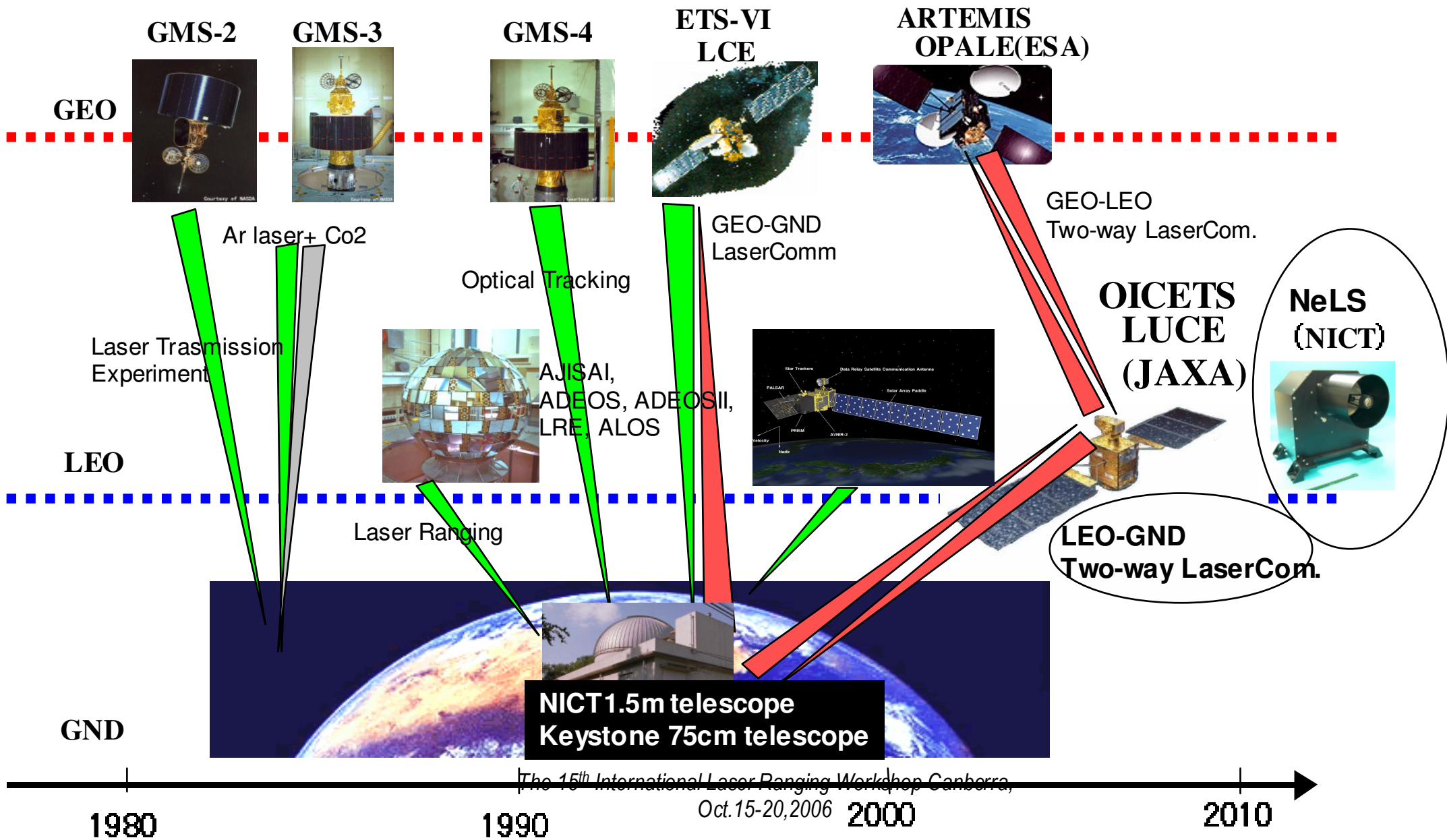
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- 1 Introduction
- 2 NeLS Optical Terminal (OE)
- 3 Tracking Demonstration by partly use of NeLS-OE
- 4 OICETS Sat.-Ground experiment

## History of Optical Tracking and Laser Communication at NICT(CRL/RRL)

-Introduction-

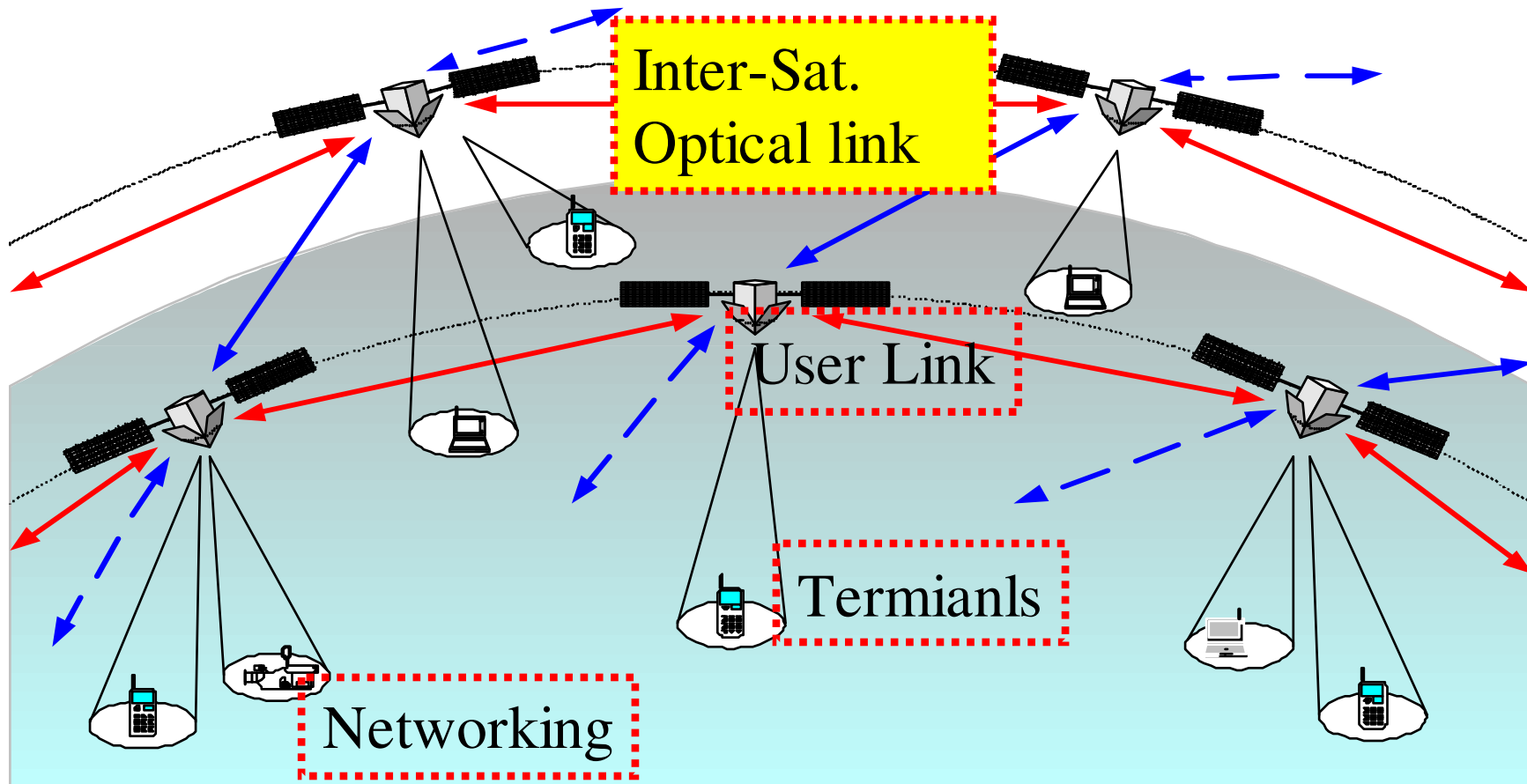


# NeLS: Next Generation LEO System

## Goal

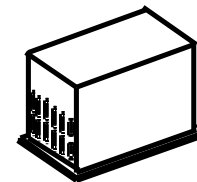
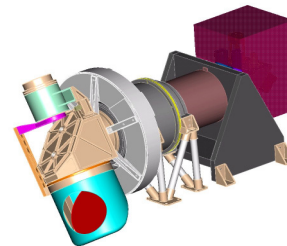
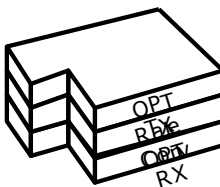
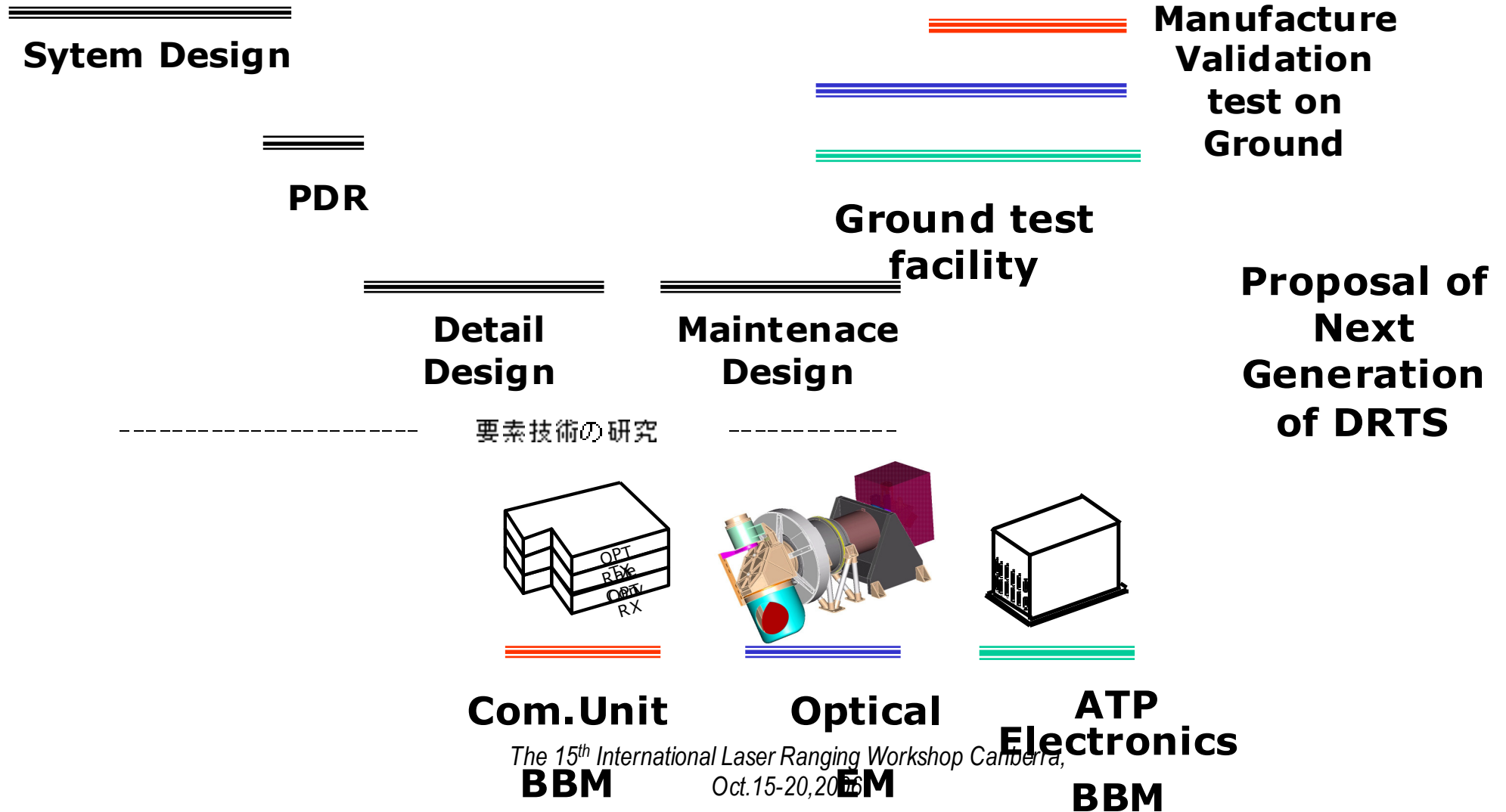
### -Introduction-

- The Next Generation LEO System Research Center (NeLS) Research Center in National Institute of Information and Communications Technology (NICT), of Japan, formed in 1997, and since 2002, has been focusing on the development of optical inter-satellite link technology for the future satellite communication demanding a high data transmission for global multimedia service, including science data downlink requirement.



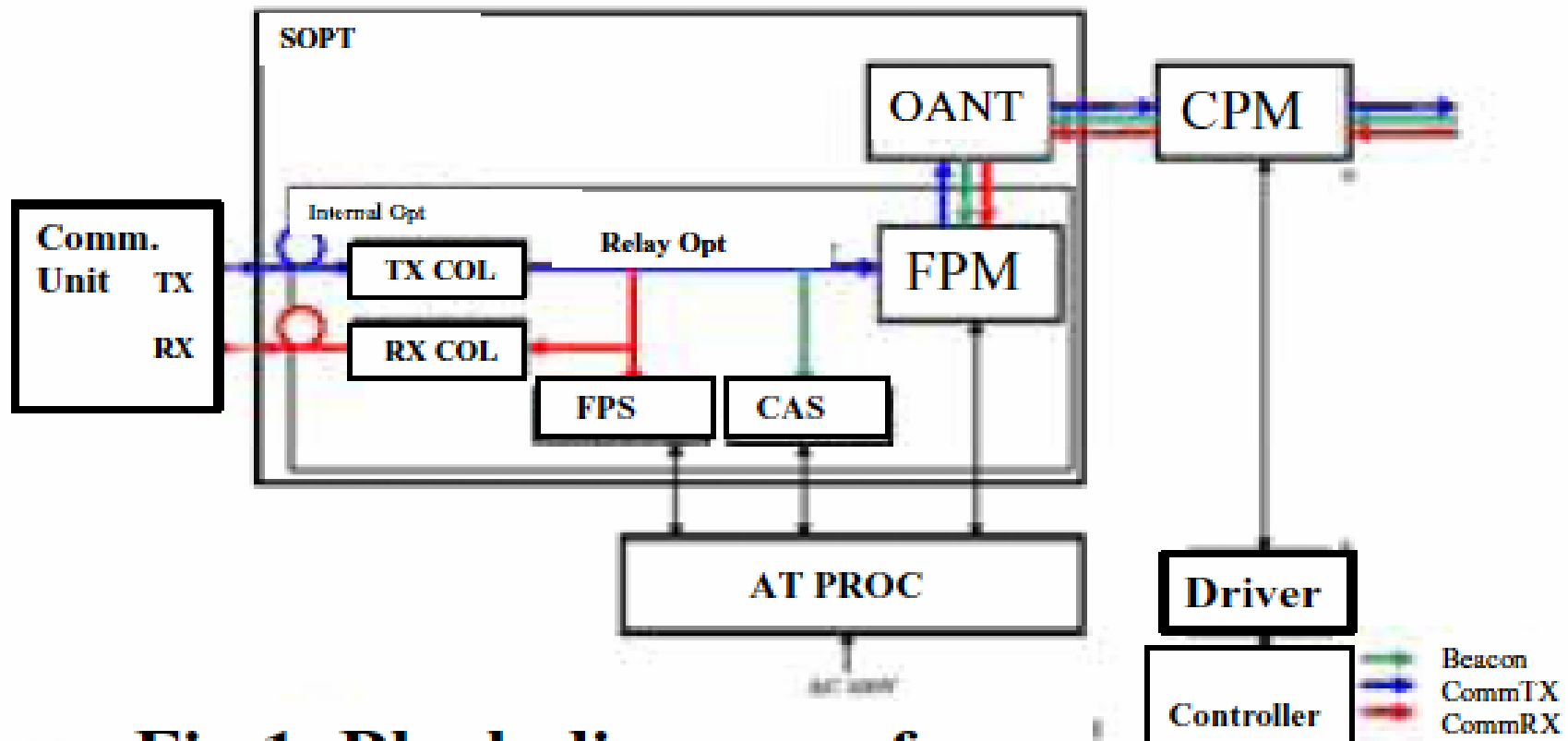
# NeLS OE Project Schedule

FY2002	FY2003	FY2004	FY2005	FY2006
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# NeLS Optical Terminal

NeLS Optical terminal was designed for 1.5 $\mu$ m wavelength and 2.4Gbps data rate communication between 500km-3000km inter-satellite link. It consists of four subsystems, as shown in Fig.1, 1) Coarse Pointing Mechanism (CPM), 2) Fixed Optical part (Antenna and FPM optics on Bench), 3) AT&P electronics Unit for Acquisition, Tracking and Pointing control, and 4) Communication Unit.

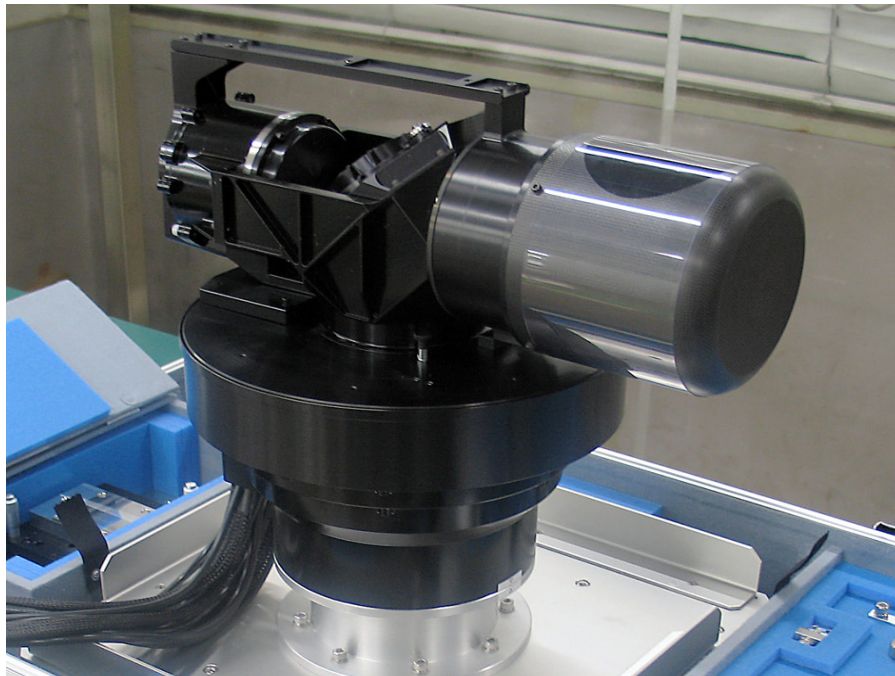


**Fig.1 Block diagram of**

# 10cm class Coarse Pointing Mechanizm (CPM)

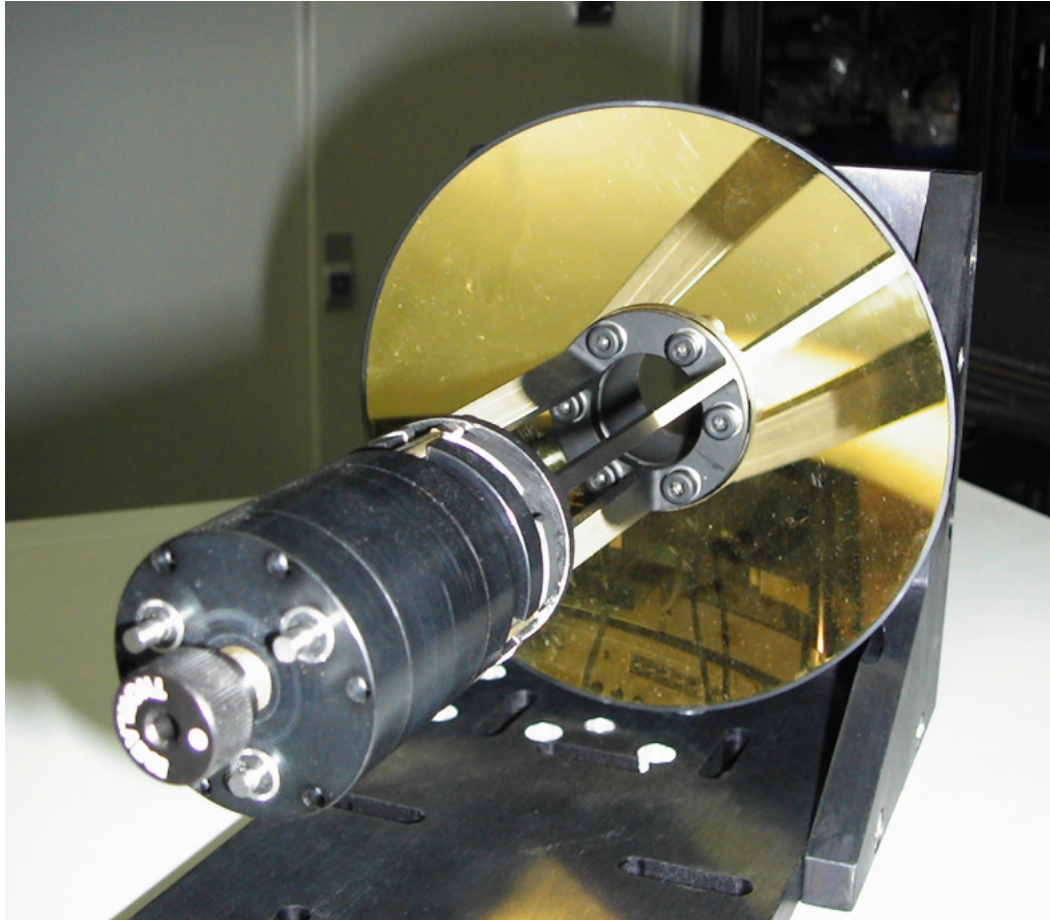
## Type Elbow

- Optical Antenna fixed to satellite body
- Moving part: two flat mirrors for guiding light through 45deg incident angle on each gimbal axis
- Cover all direction in space



<b>Item</b>	<b>Specification</b>
<b>Range of drive axis</b>	<b>Az: +/-275deg EL: +/-110deg</b>
<b>Maximum drive speed</b>	<b>3.0deg(slew) 1.0deg(track)</b>
<b>Effective aperture size</b>	<b>85mm</b>
<b>Resolution of encoders</b>	<b>2/10000deg</b>
<b>Weight</b>	<b>16kg</b>





Optical Antenna  
Type: Cassegrain  
Tripod supports  
structure for secondary  
mirror  
125mm diameter  
Material:SiC  
Gold Coating  
TF1:2600mm

# Key components internal optics



Fine Pointing Mirror (FPM)



Transmitting Fiber Coupler (left)



Receiving Fiber Coupler & QD (right)



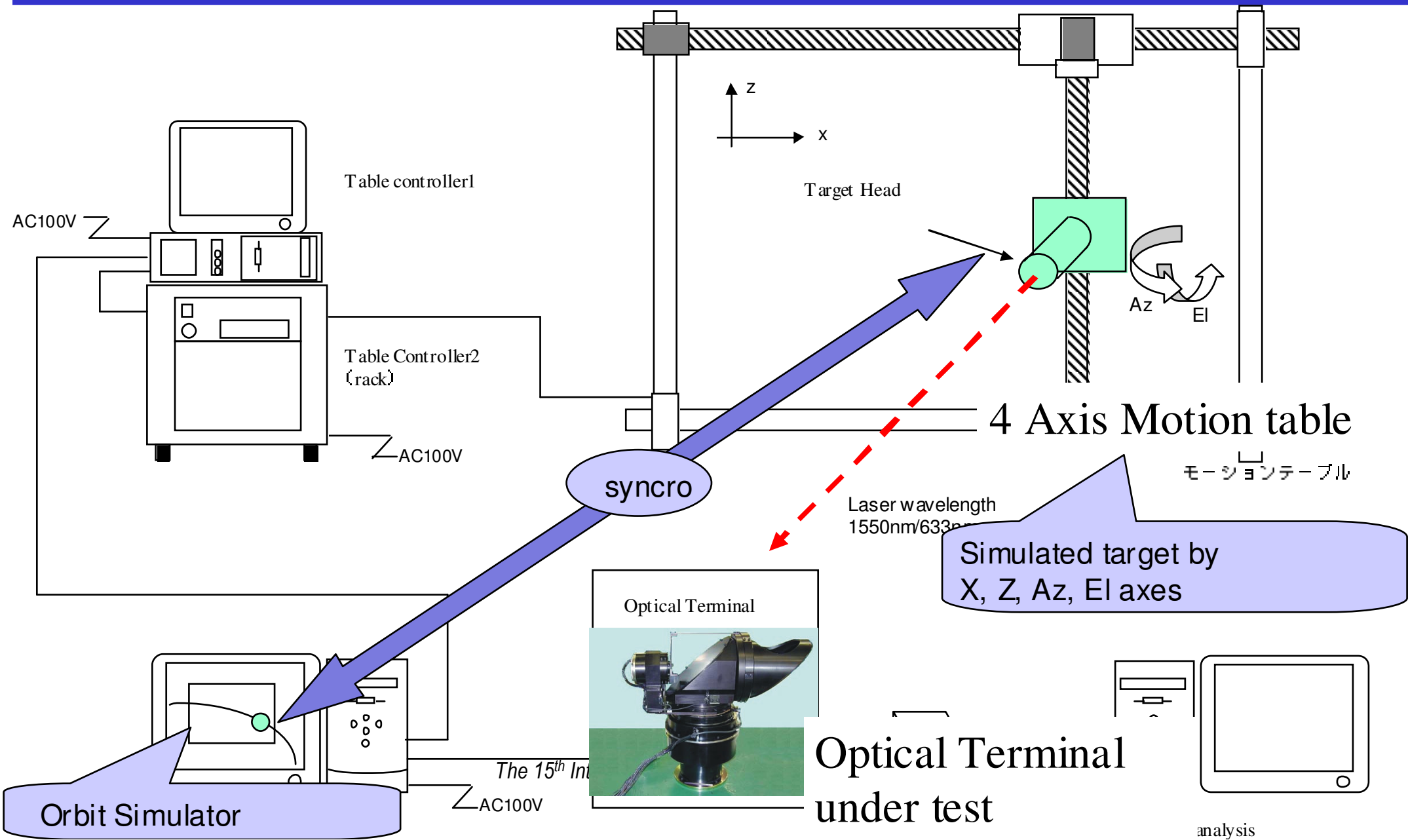
# Goal of ground test

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- Evaluate ATP Performance and Communication performance Near field (range 5m-4km)
- Validate Open Loop tracking capability using CPM and Optical Antenna by Associated Satellite Laser Ranging subsystem.

# NICT Utility development for Ground experiment

## -Ground Test-





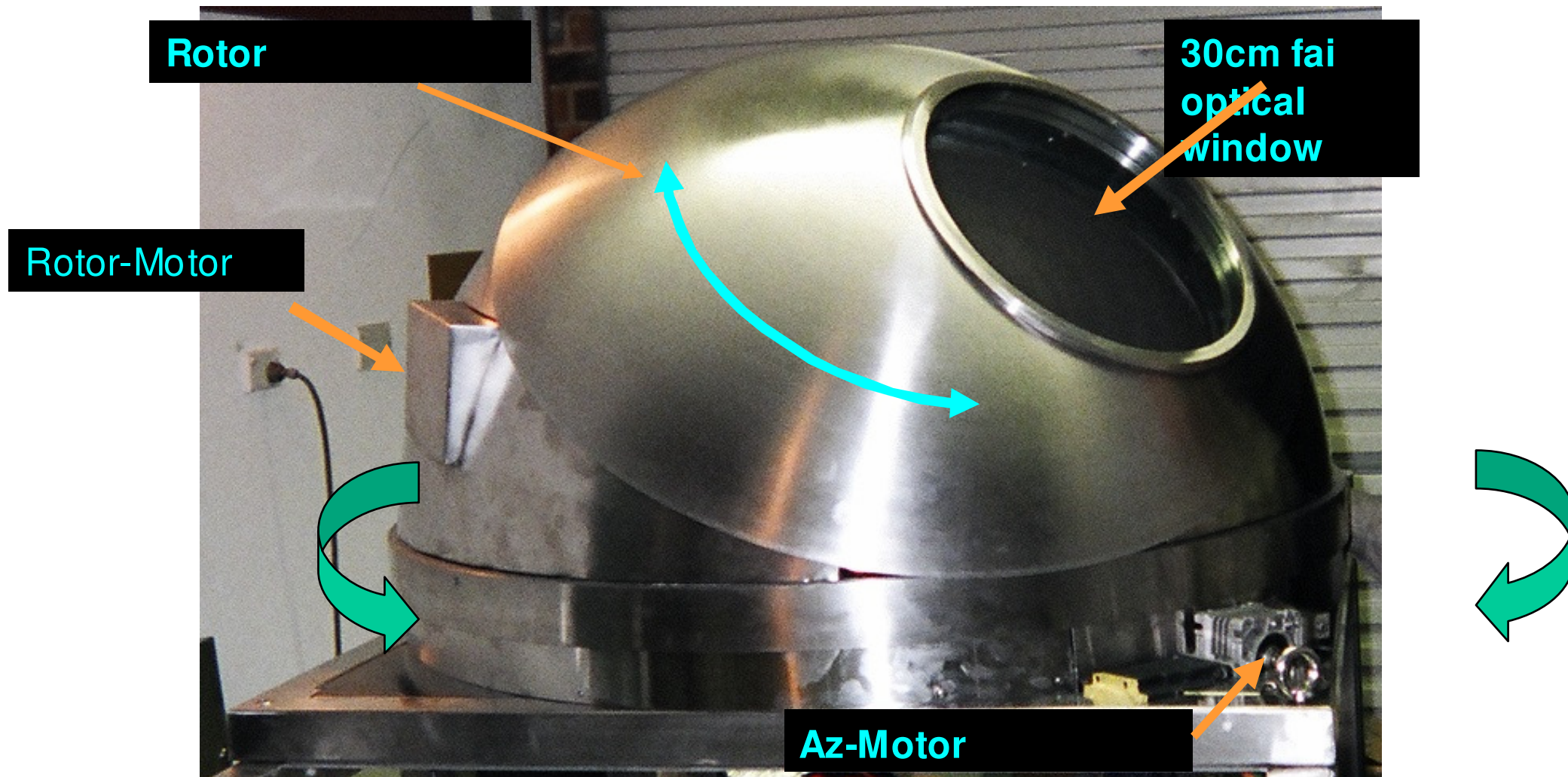
**Dome housing for Optics and Electronics for Ground Experiment**

**CPM Mount, and driver unit for Ground Experiment**

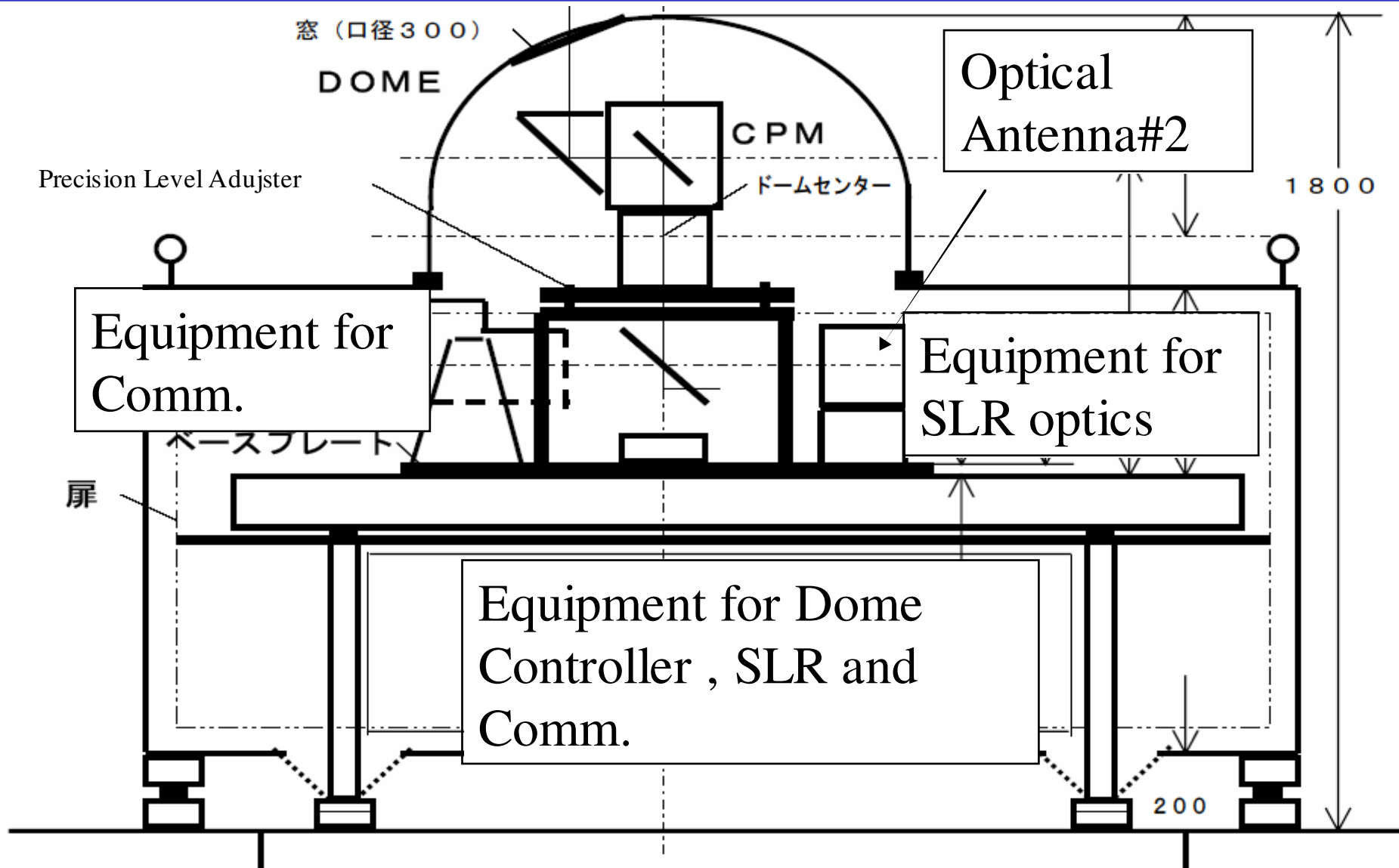
**Chiller for dome**



# Mobile Dome

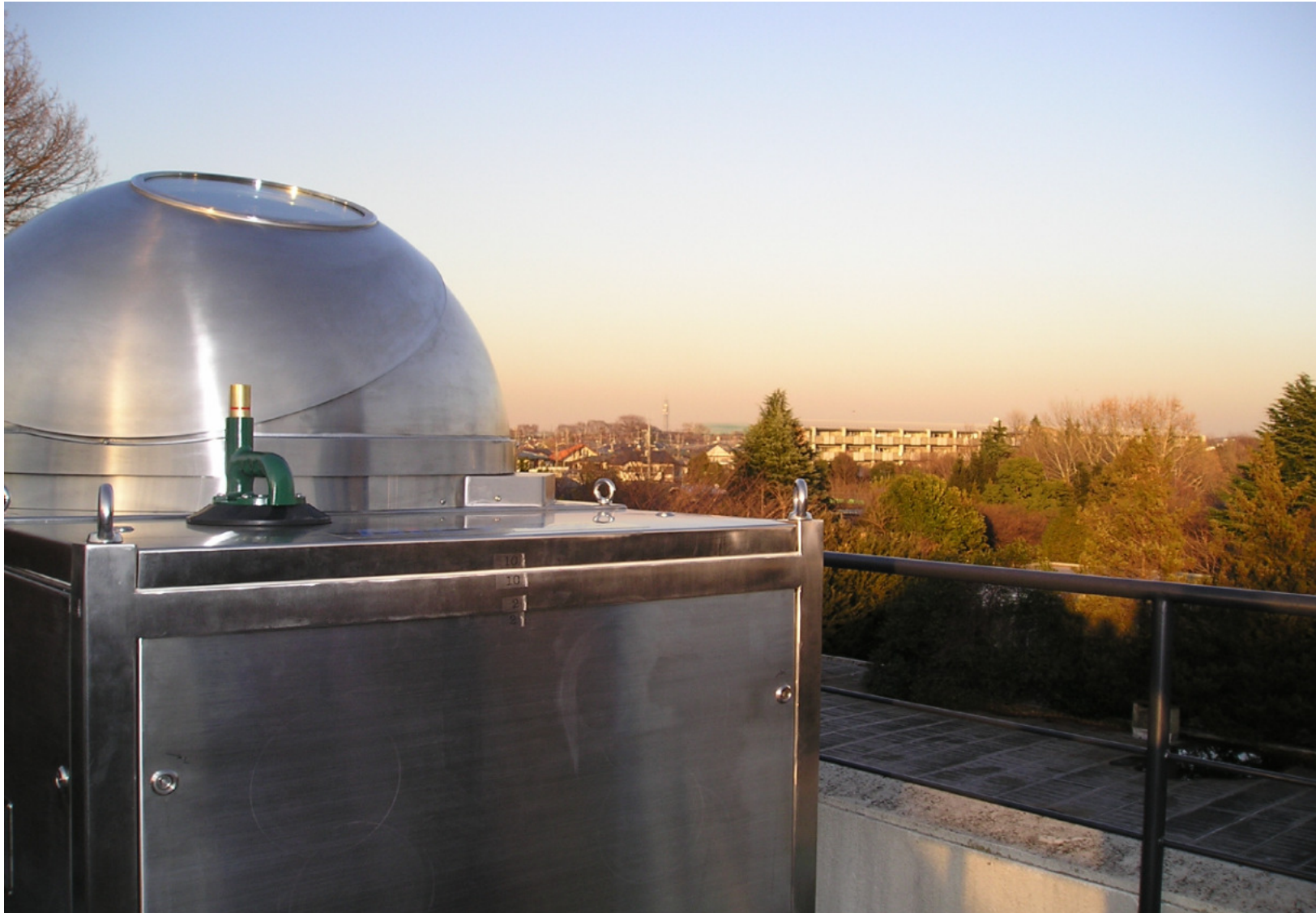


-Ground Test-



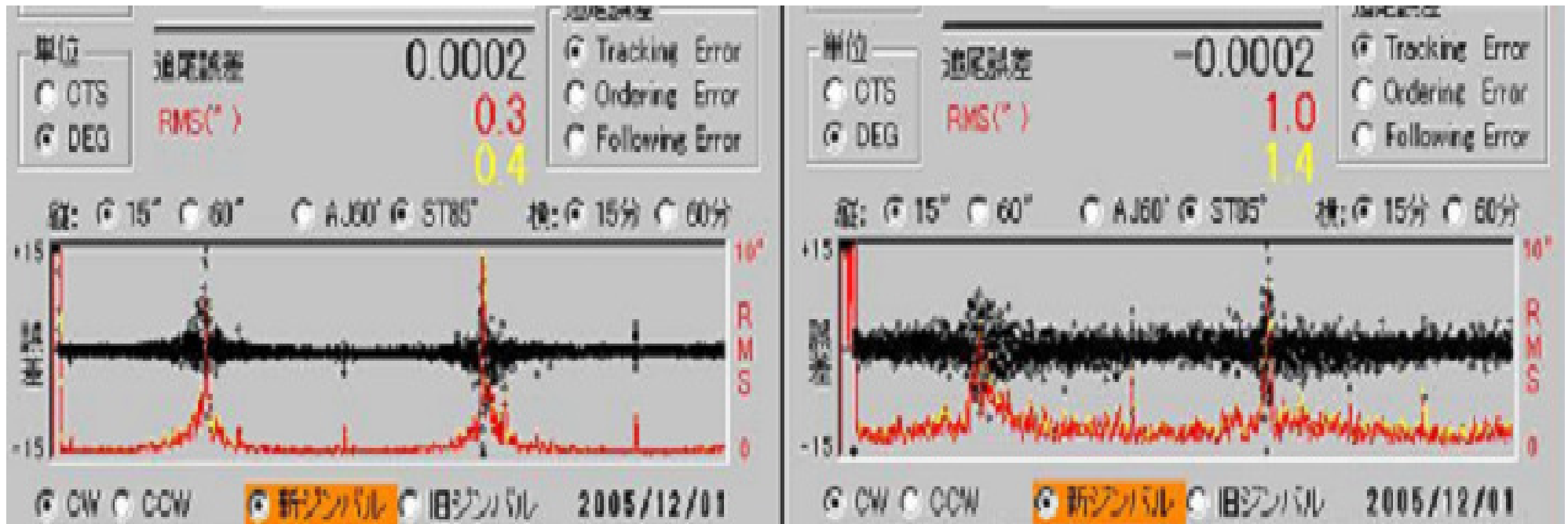


# Dome at building Koganei



Black dot: Following Error Axis range+- 15arcsec

Red dot error RMS(2sec average) Axis range 0-10arcsec



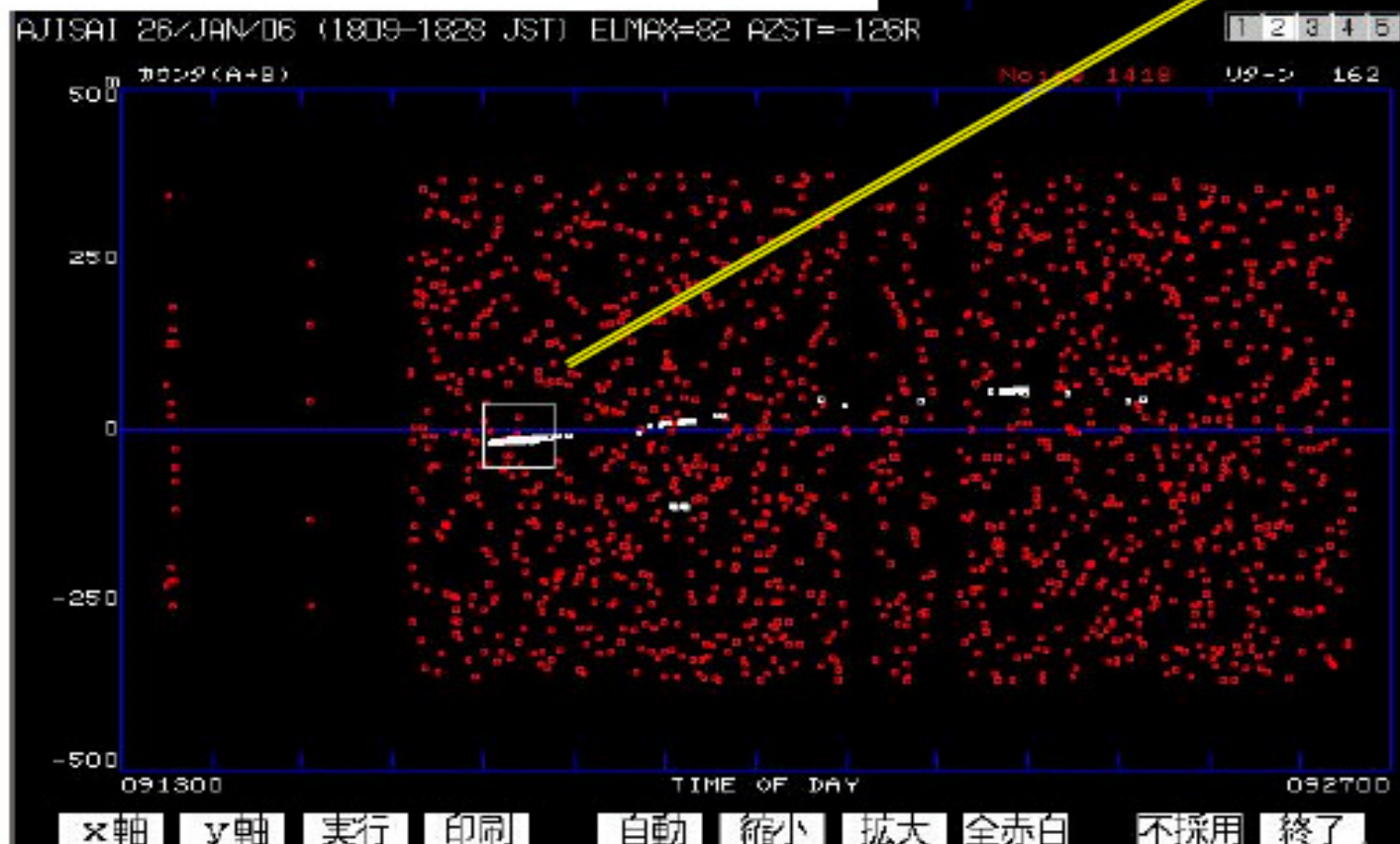
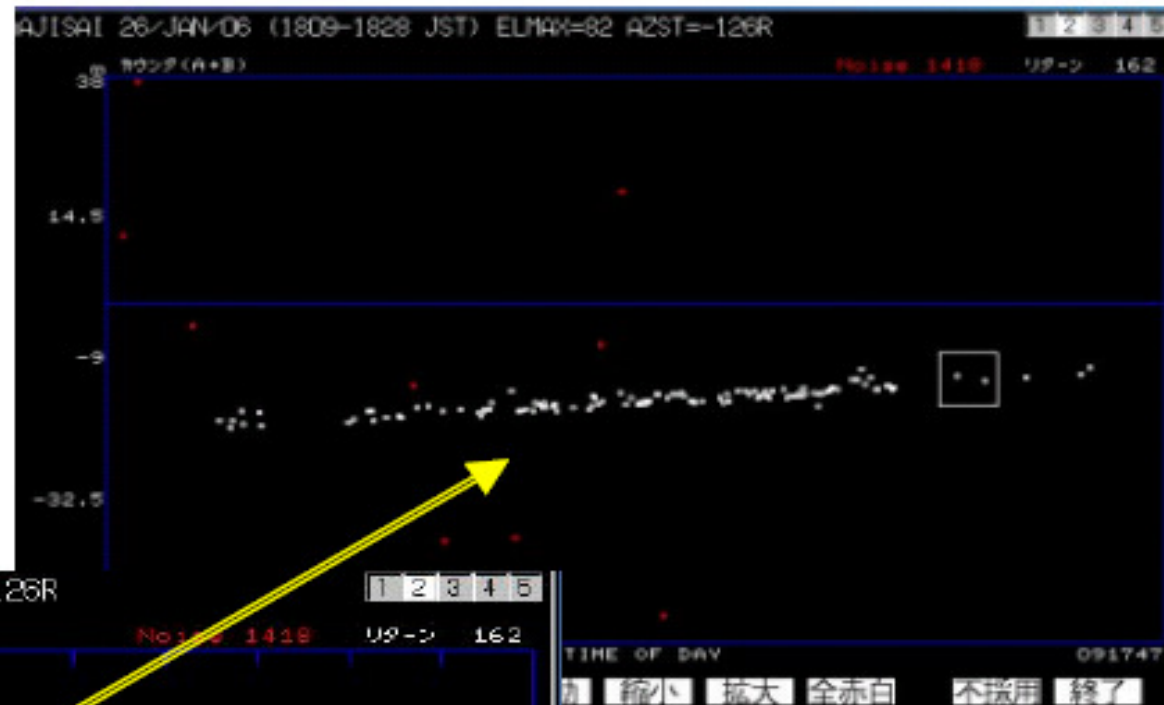
AZ axis:

<1arcsec rms except around zenith  
about 10arcsec rms

EL axis:

< 2arcsec rms except around  
zenith about 6 arcsec rms

AJISAI First Return pass  
record by NeLS CPM  
Using NS 10Hz 532nm  
A032ET  
C-SPAD  
January 26, 2006



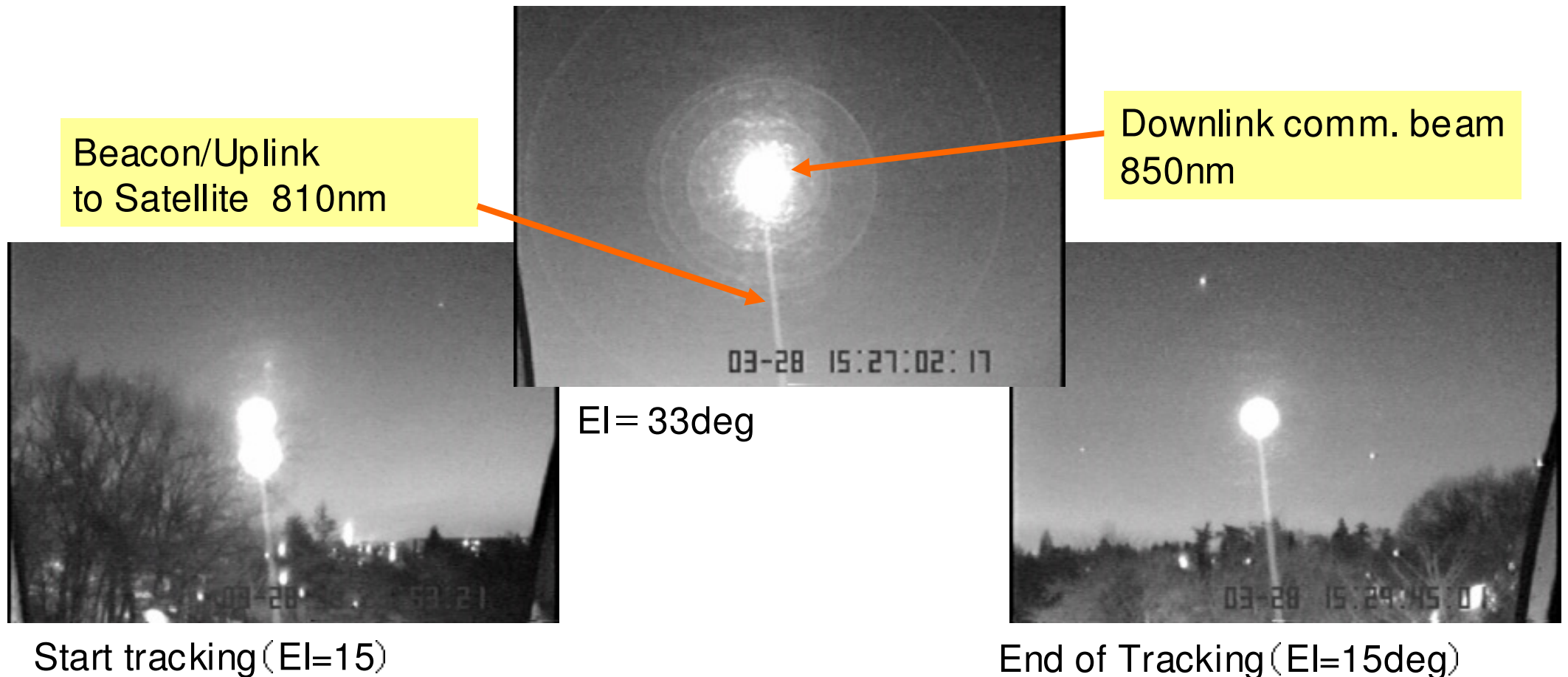
## -Ground Test-

?	xxxxxx	AJISAI	19/JAN/06	(1824-1841 JST)	ELMAX=38	AZST= 193L	
?	xxxxxx	AJISAI	24/JAN/06	(1756-1815 JST)	ELMAX=67	AZST= 215L	
?	xxxxxx	AJISAI	24/JAN/06	(2203-2220 JST)	ELMAX=32	AZST= -63R	
?	xxxxxx	STARLETTE	25/JAN/06	(2140-2154 JST)	ELMAX=36	AZST= -45R	
?	xxxxxx	AJISAI	25/JAN/06	(2311-2329 JST)	ELMAX=39	AZST= -50R	
★	△	xxxxxx	AJISAI	26/JAN/06	(1809-1828 JST)	ELMAX=82	AZST=-126R
?	xxxxxx	AJISAI	26/JAN/06	(2013-2030 JST)	ELMAX=37	AZST= -83R	
?	xxxxxx	AJISAI	27/JAN/06	(1918-1936 JST)	ELMAX=45	AZST= -96R	
?	xxxxxx	AJISAI	28/JAN/06	(2027-2044 JST)	ELMAX=33	AZST= -70R	
★	△	xxxxxx	AJISAI	04/FEB/06	(2015-2033 JST)	ELMAX=37	AZST= -52R
?	xxxxxx	AJISAI	10/FEB/06	(1854-1912 JST)	ELMAX=39	AZST= -51R	
?	xxxxxx	AJISAI	10/FEB/06	(2056-2115 JST)	ELMAX=89	AZST= -51L	
?	xxxxxx	AJISAI	11/FEB/06	(1759-1817 JST)	ELMAX=34	AZST= -55R	
?	xxxxxx	AJISAI	11/FEB/06	(2002-2021 JST)	ELMAX=67	AZST= -49R	
?	xxxxxx	JASON-1	11/FEB/06	(2131-2148 JST)	ELMAX=72	AZST=-145R	
?	xxxxxx	AJISAI	11/FEB/06	(2204-2222 JST)	ELMAX=39	AZST= -61L	
★	△	xxxxxx	AJISAI	13/FEB/06	(1813-1831 JST)	ELMAX=41	AZST= -50R
?	xxxxxx	AJISAI	13/FEB/06	(2015-2035 JST)	ELMAX=84	AZST= -51L	
★	△	xxxxxx	AJISAI	14/FEB/06	(1921-1940 JST)	ELMAX=71	AZST= -49R



## OICETS: VIEW of CCD Camera

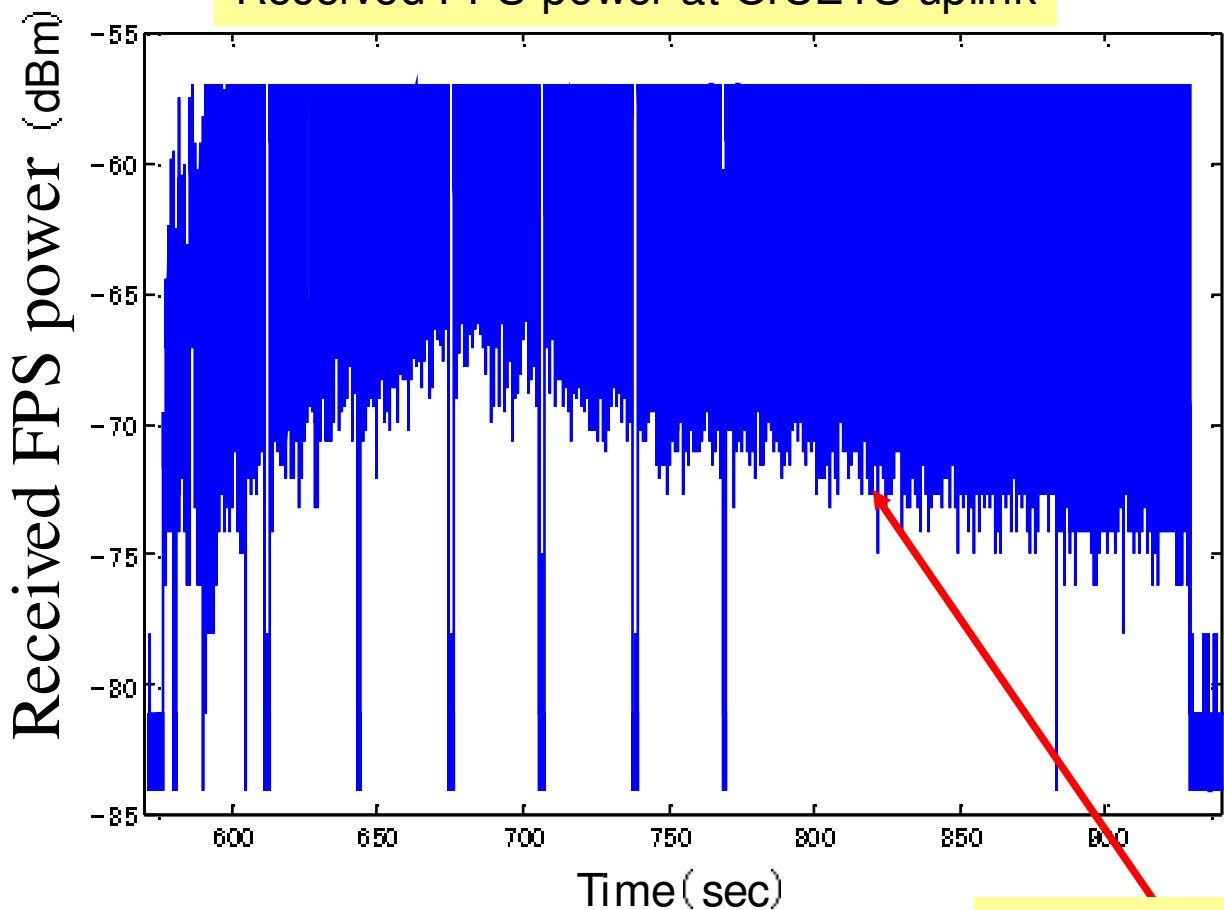
- At Koganei 1.5m telescope on March 29, 2006
- Up to September, BER 10<sup>-5</sup> in both Downlink(50Mbps) and Uplink(2Mbps) channel.



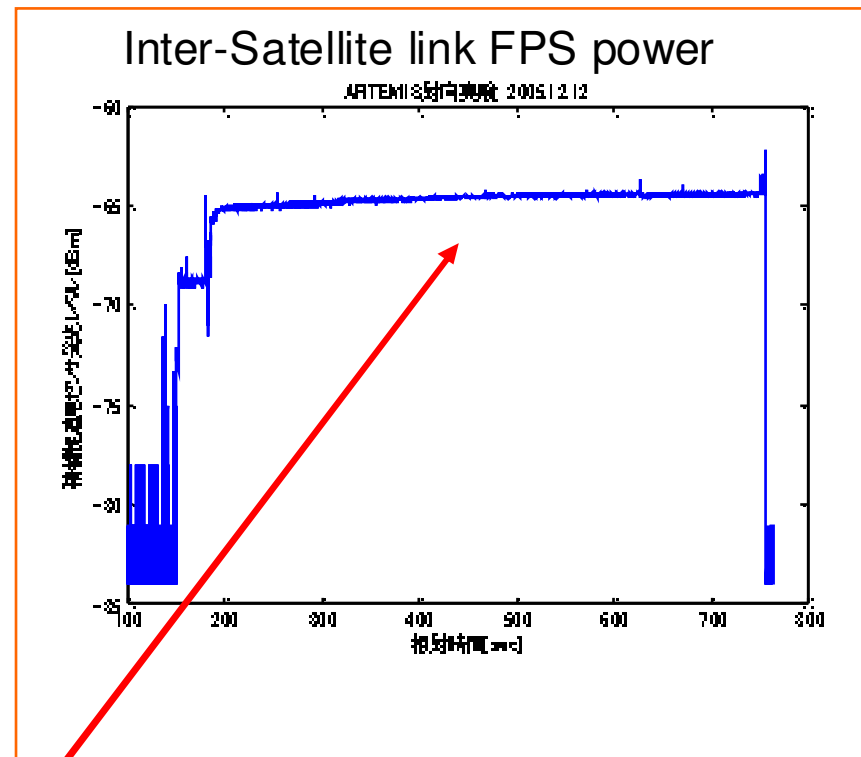


## Received power stability through atmosphere

Received FPS power at OICETS uplink



Mean -63.17 dBm  
 Sd( $3\sigma$ ) 14.04



Effect of with and without atmosphere turbulence

JAXA

# Summary

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- The Next Generation Inter-satellite LaserCom. (NeLS) Terminal Optical Part Engineering Model has been developed.
- By using newly developed utility for ground test validation, such as 4 axis motion table, mobile dome, optical terminal for 1.5um wavelength and 2.4Gbps data rate was evaluated in nearfield (5m-5km) including ATP performance with atmospheric existence.
- Using Coarse Pointing Mechanism (CPM) and 10 cm class Optical antenna and, and associated 532nm pulse laser connection pass, we have demonstrated open-loop tracking capability by ranging to AJISAI.
- The present generation of LaserComm satellite (OICETS) results including atmospheric effect briefly shown.
- Next Step is now using evaluation of those, we are proposing the next generation of DRTS(Data Relay Technology Satellite) in early 2010's