Propagation Experiment of COMETS Ka/Q-band Communication Link for Future Satellite Cellular System

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Background

Mobile/Personal Satellite Communication Systems in L/S-bands are going into the operational phase. In the future, they will be operated in much higher frequency bands, for example in Ka-band, because the available bandwidth in L-band is limited. Systems with large on-board antennas in higher frequencies allow the same configuration as terrestrial cellular radio systems, since the on-board antennas will have many small spot beams. This may be true especially in a low earth orbit system such as Teledesic, which will use Ka-band.

The most important parameter of Satellite Cellular may be cell size, that is, a diameter of the spot beam. A system designer needs the local correlation data in a cell and the size of the correlative area. On the other hand, the most significant difficulty of Ka and higher band systems is the countermeasure to rain attenuation. Many-cell systems can manage the limited power of on-board transponders by controlling output power of each beam depending on the rain attenuation of each cell. If the cell size is equal to the correlative area, the system can probably achieve the maximum performance.

Propagation data of Ka and higher band obtained in the past shows a long term cumulative feature and link availability, but do not indicate the correlative area. The Japanese COMETS satellite, which will be launched in February 1997, has transponders in Ka and Q-band. The CRL is planning to measure the correlative area using 21GHz and 44GHz CW transmissions from the COMETS.

Propagation Research Plan

Earth stations with a receive-only function are set up in the meshed configuration with several km intervals, for example, 3x3 or 4x4. The functions of earth stations are to measure received level, precipitation, and cloudiness. Data from the stations are measured simultaneously, and recorded by data recorders or real-time transmitted to a center through a public telephone network. As the interval of meshed earth stations will be a parameter of this measurement, it will be changed in a certain period, for example, one year. Due to the different intervals, the measurement can be expanded in its dynamic range with a limited number of earth stations.

Accumulated data will be analyzed to estimate the correlative area. As the attenuation due to clouds is not negligible especially in mm-wave such as Q-band, the relation between a fade level and the cloudiness may be an interesting target for analysis.

In our tentative plan, the development of a bread-board model of the earth station will start this year, and at least 9 stations in Ka-band will be developed before the satellite is launched. The most significant difficulty in this research is the cost of receivers and antennas. As we would like to prepare many stations, we need cost effective antennas and receivers.

CRL's Propagation Research in Ka-band, mm-Wave and Optical Satellite Links

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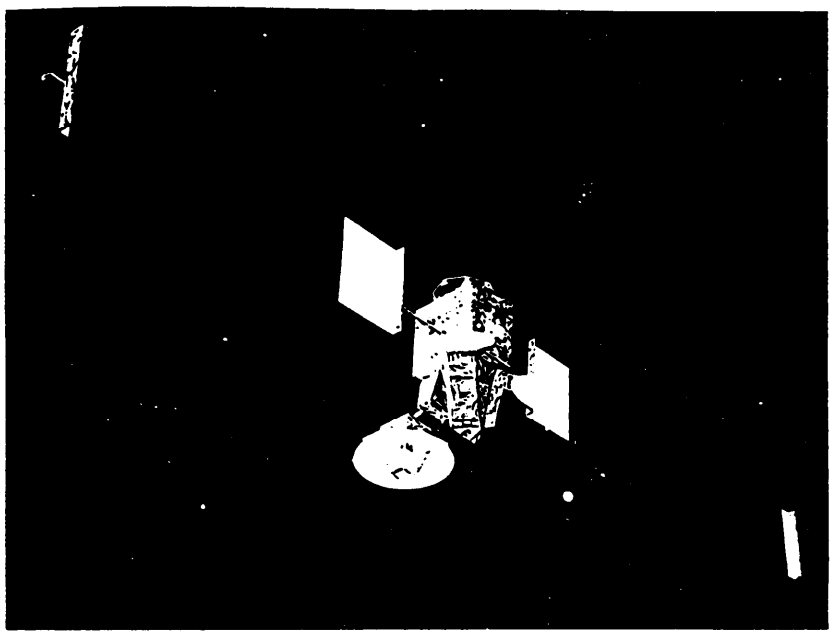
1. Propagation Experiment of ETS-VI Optical Communication Link (Preliminary Result)
2. Propagation Experiment of COMETS Ka/Q-band Communication Link (Future Plan)

COMETS Satellite



COMETS Project

Experimental Missions

Advanced Mobile Satellite Comm. (CRL)
Advanced Satellite Broadcasting (CRL/NASDA)
Inter-orbit Communication (NASDA)

Objectives of Advanced Mobile Sat-Com

To develop basic technology of future mobile/ personal satellite communication in Ka / mm-wave bands.

Features

Regenerative Transponder (SCPC/TDM)
Beam Interconnection

On-board Equipment

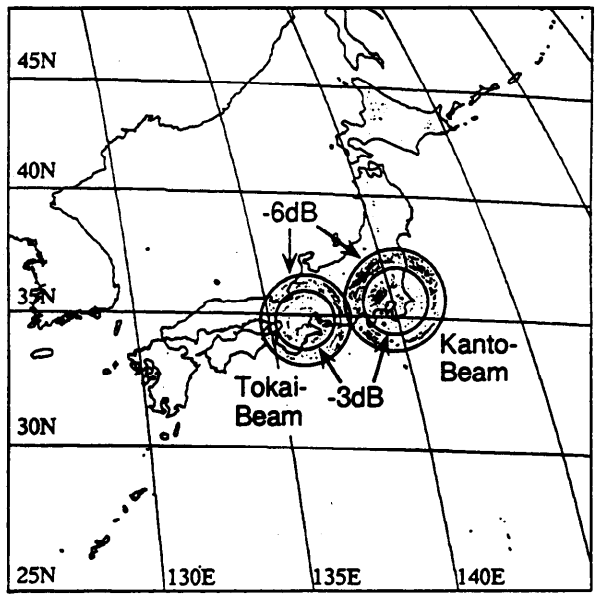
Mobile Mission

Freq.	: 21GHz	/ 44GHz
Tx Power	: 20W	/ 20W
ANT Gain	: 48dBi	/ 54dBi (2m)
EIRP	: 58dBW	/ 61dBW
Polarization	: LHCP	

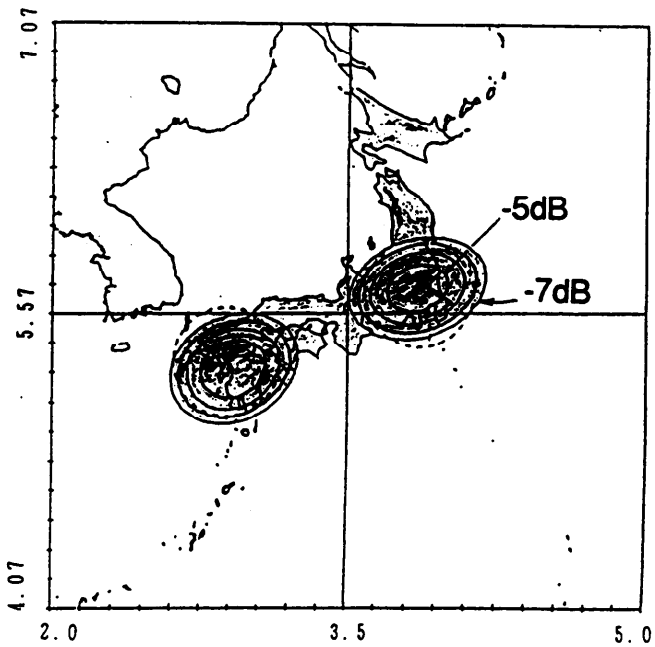
Broadcasting Mission

Frequency	: 20.7GHz
Tx Power	: 200W
ANT Gain	: 46dBi (2.3m)
EIRP	: 66dBW
Polarization	: RHCP

On-board Antenna Radiation Pattern in Ka-band



Radiation Pattern of Broadcasting ANT



Future Mobile / Personal Satellite Communication

High Frequency
High EIRP
Low Earth Orbit

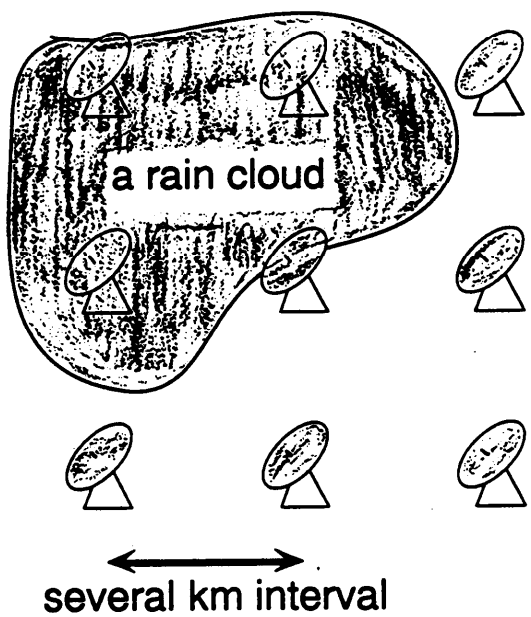
→

Satellite
Cellular

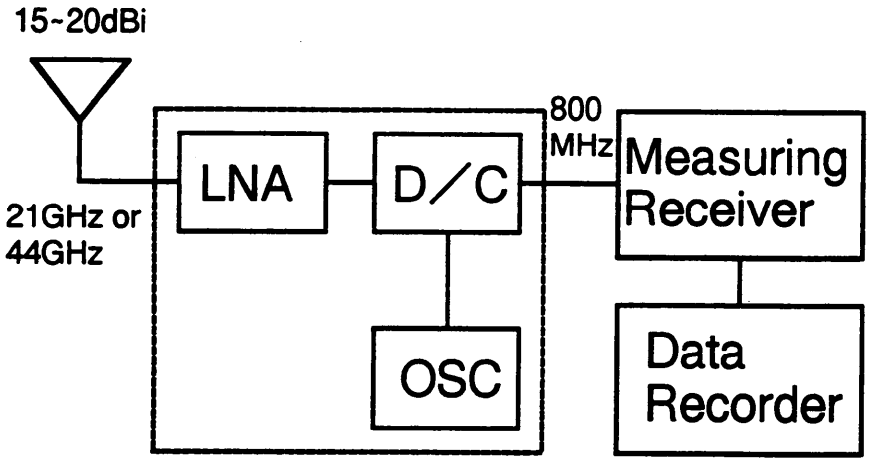
Cell size (spot beam size) will be the most important parameter from the viewpoint of rain attenuation.

Because the EIRP of each cell will be controled depending on the link condition of each cell.

Propagation Measurement Configuration



Simple Earth Station Hardware



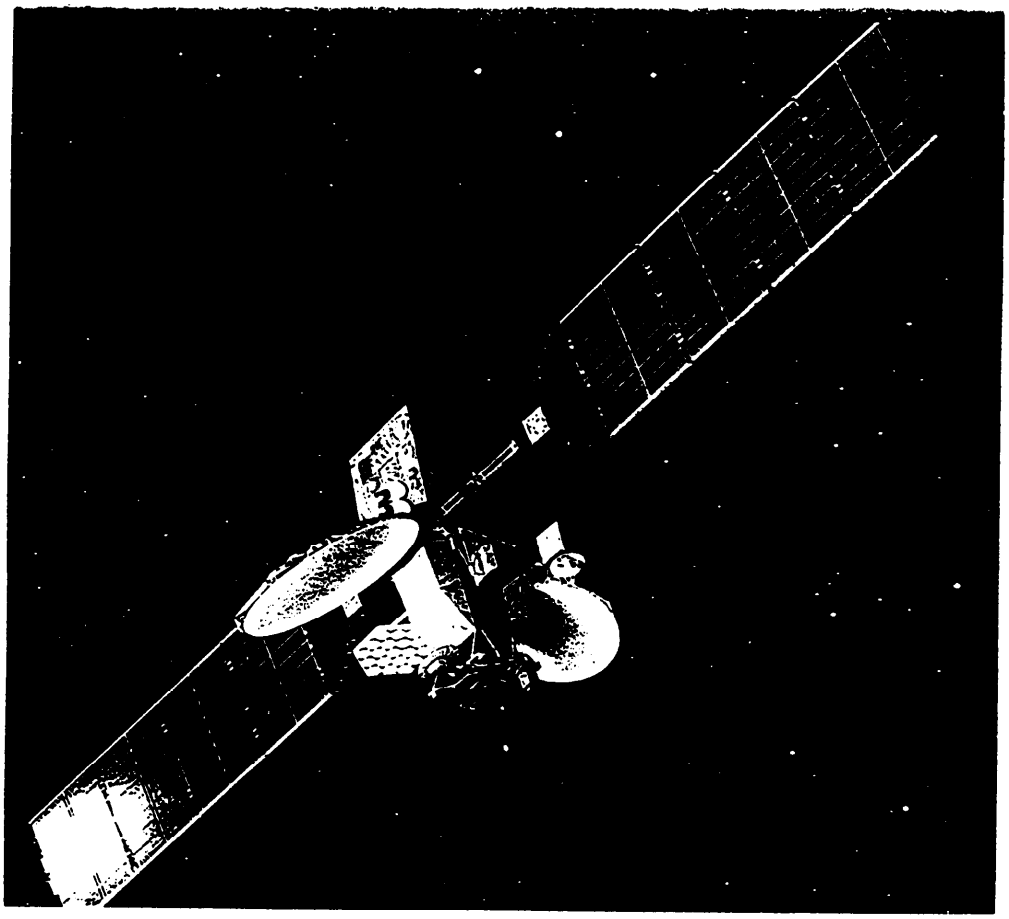
Summary

Propagation research for future satellite cellular communications

Using COMETS Ka/Q-band Transponders

Simultaneous measurement with array configuration of simple earth stations

Estimation of correlative area / cloud's effect



Current status of the ETS-VI satellite

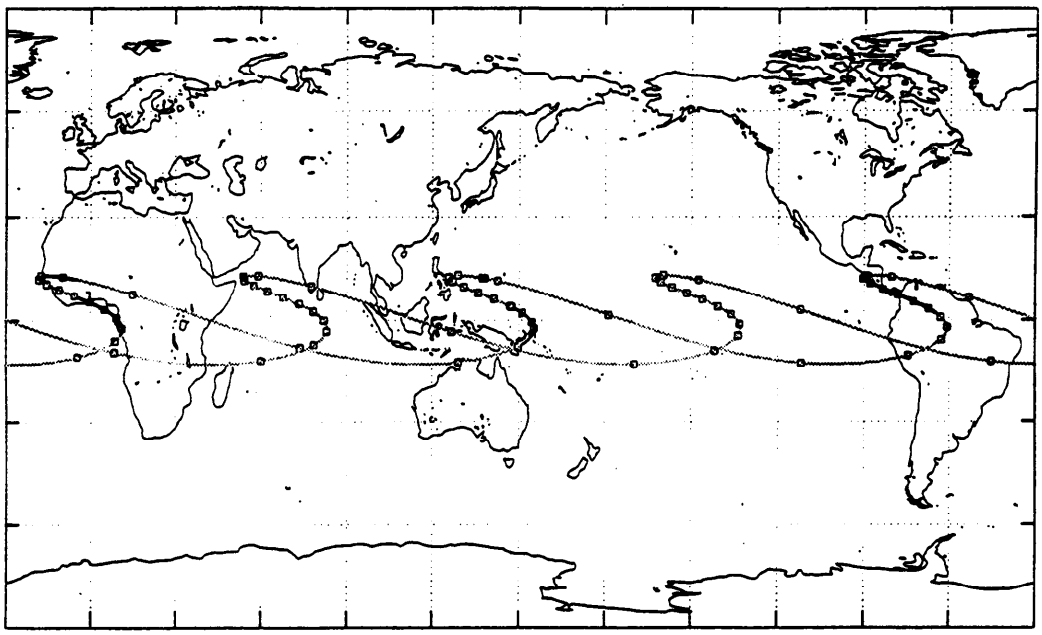
- ETS-VI was launched on 28 August 1994 with a laser communication payload called LCE (Laser Communication Equipment).

- In November, ETS-VI was transferred into 3-day subrecurrent orbit suitable for communication experiment.

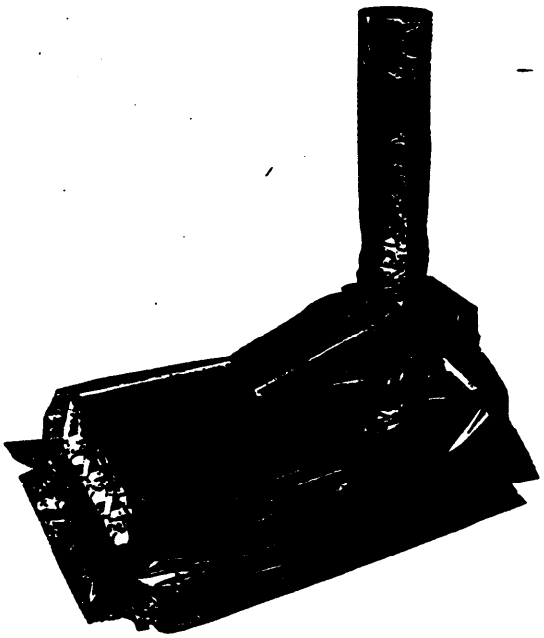
- It is necessary to make attitude bias-control by leaning the antenna pointing for communication with Japanese ground station.

- Because of the strong radiation effects in the Van Allen belt, electric power of the solar array is decreasing and this will limit the satellite lifetime.

Subrecurrent orbit of ETS-VI (three-day period)

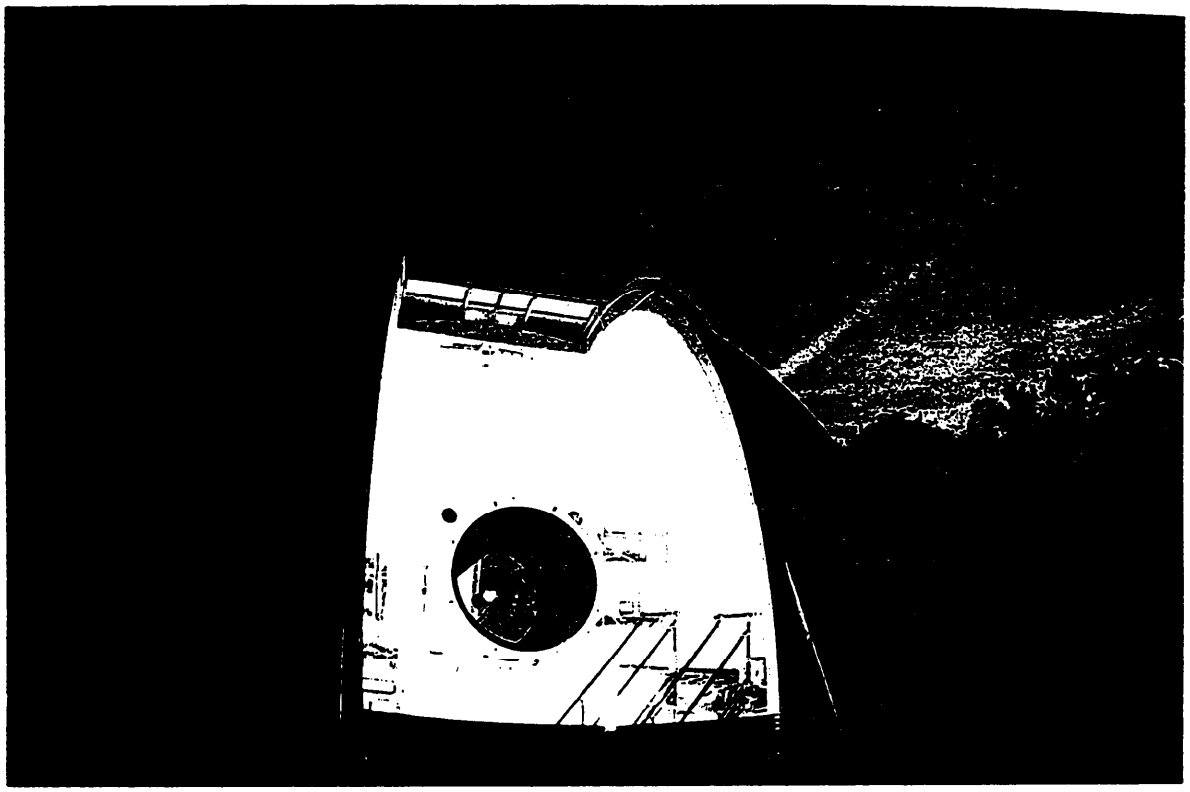


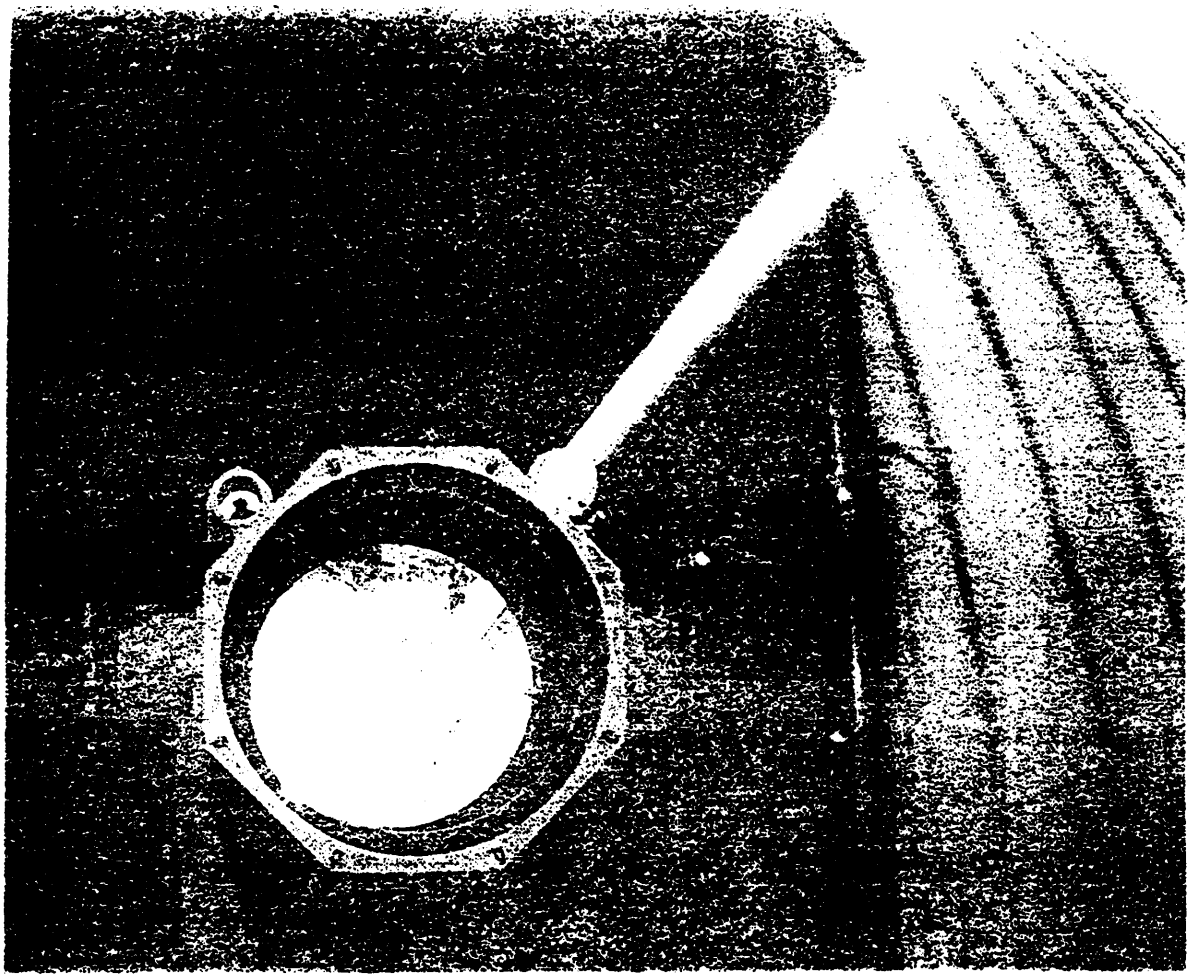
Three-day prediction of subsatellite point from Dec. 12, 1994, marker interval: 0.5 hour, thick line shows accessible region from ESA, Japan, and USA.



LCE光学部
LCE Optical Part

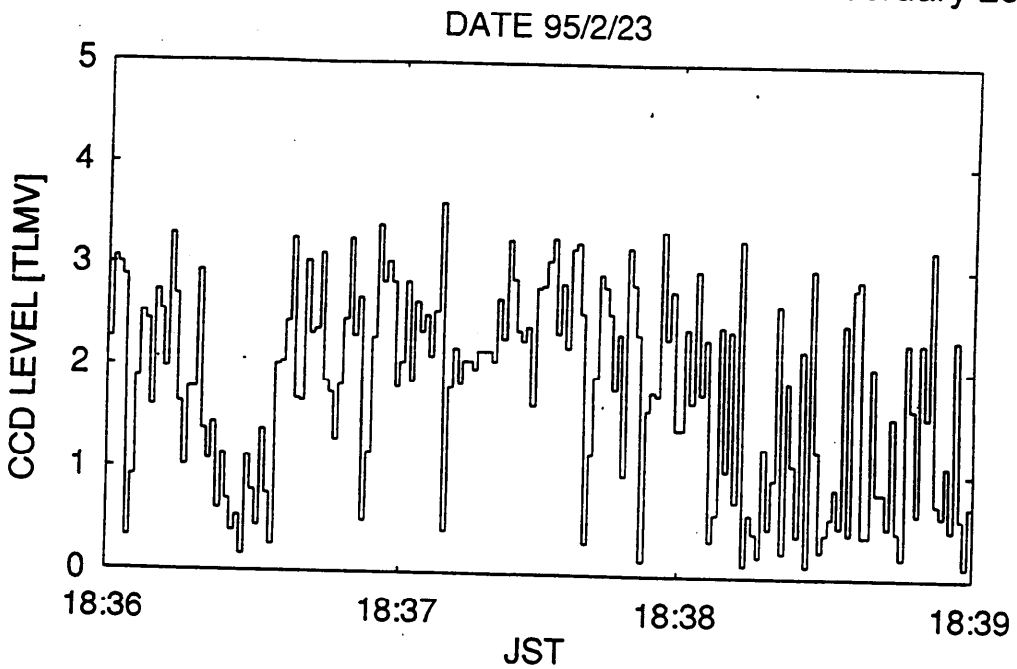
LCE光学部の内部
Layout of the LCE Optical Part





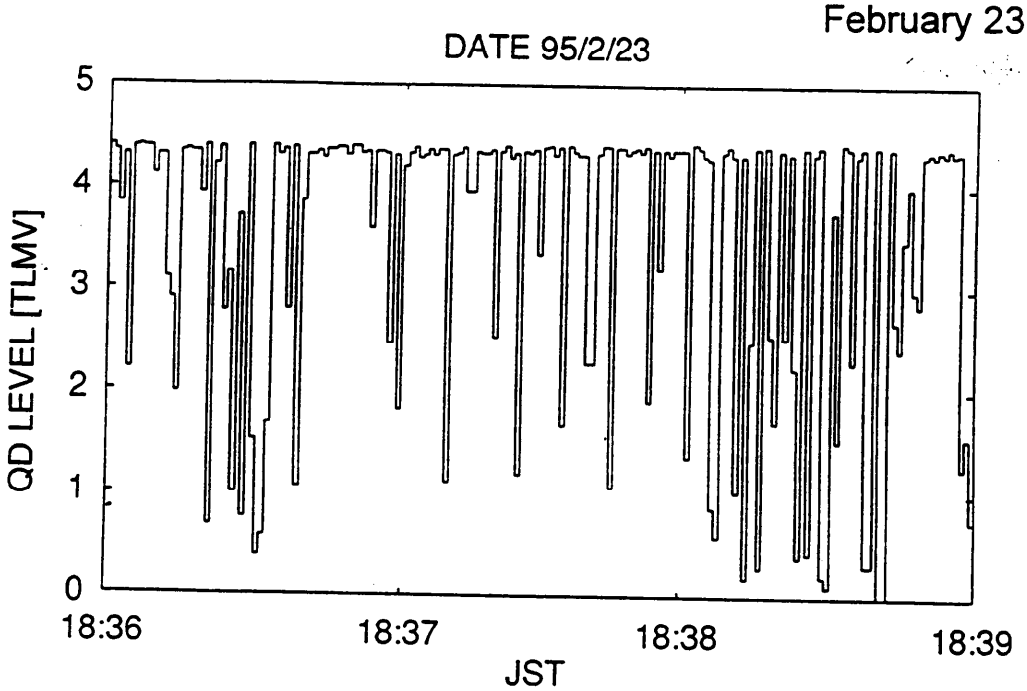
Receiving level of onboard CCD tracking sensor

February 23, 1995



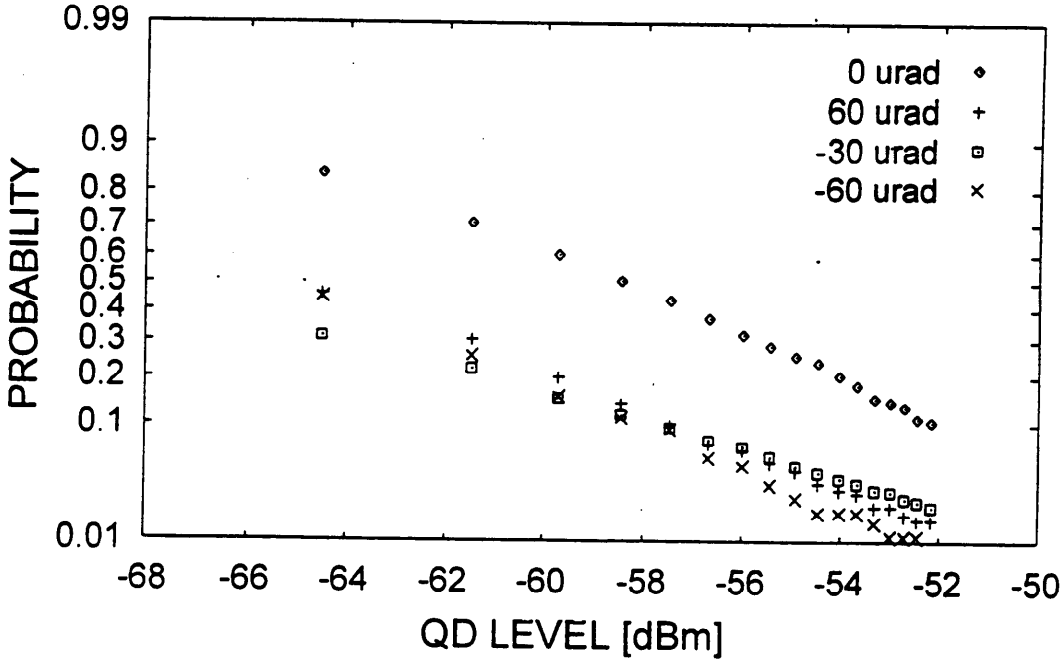
Receiving level of onboard fine tracking sensor (QD)

February 23, 1995



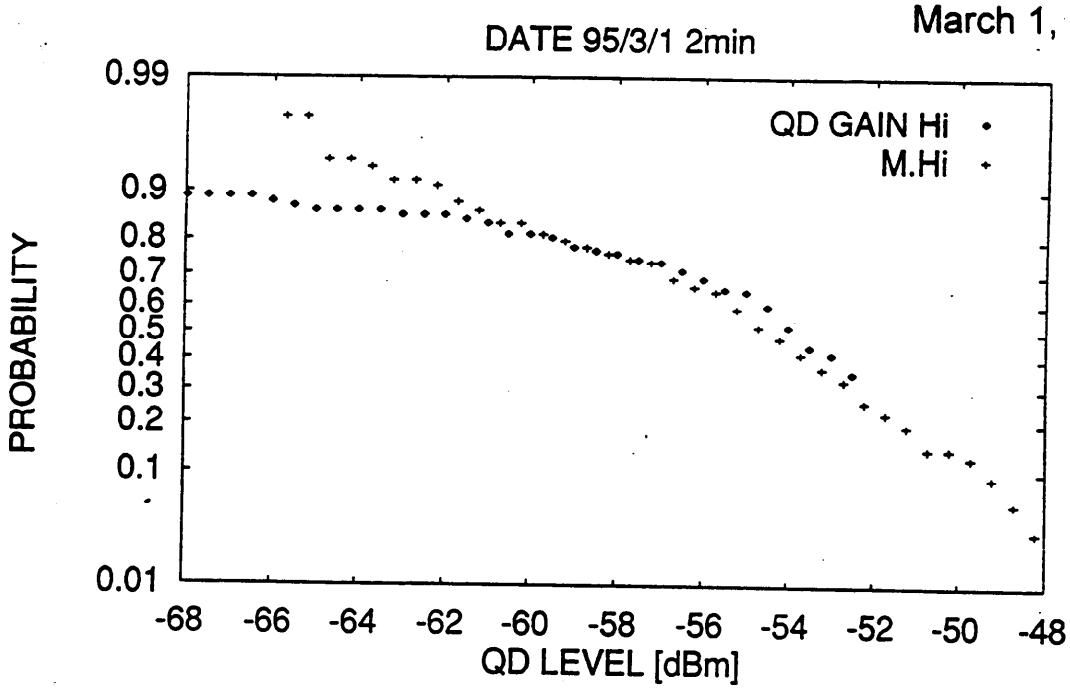
Cumulative probability of receiving laser power

January 15, 1995

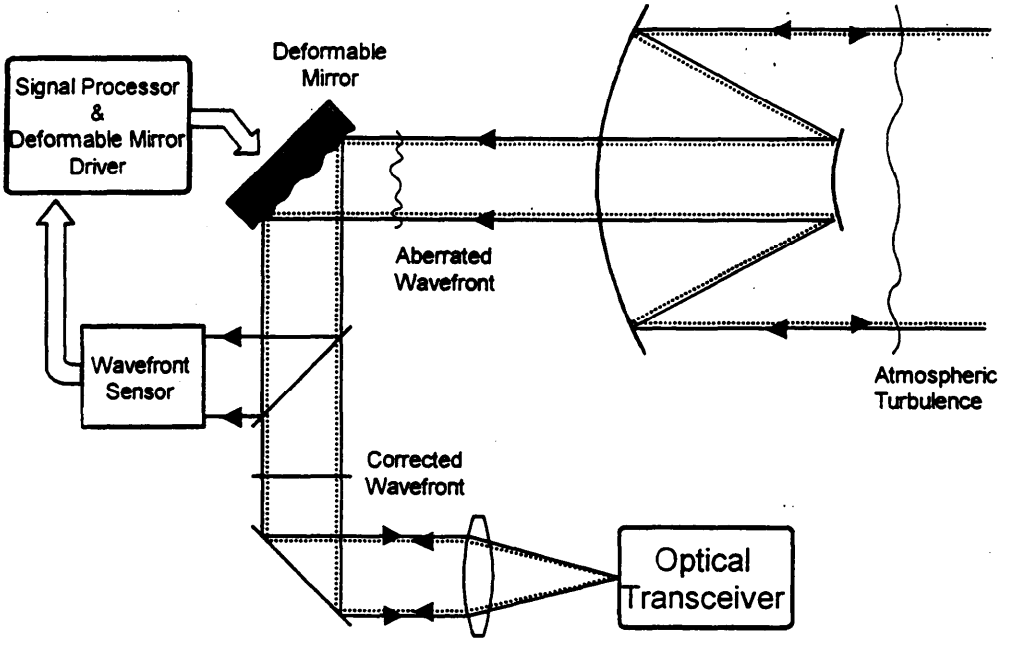


Cumulative probability of receiving laser power

March 1, 1995



Application of Adaptive Optics for LaserCom



Conclusion

- All components and subsystem in the LCE are normal at present.
- LCE can be accessed from anywhere in the world if the satellite attitude can be maintained to point to the target ground station.
- There exist severe attenuation and scintillation in uplink laser light caused by atmospheric turbulences.

  and the variation of the scintillation gives good agreement with the log-normal distrobution.
- Adaptive optics will be able to decrease the severe attenuation (due to atmospheric turbulence) of up-link laser light in the ground-based laser communication experiment.