IEEE Milestone registration material

Design and Operation of Usuda Deep Space Center and Associated Control System

July 7, 2024

ISAS

MitsubishiElectricCorporation

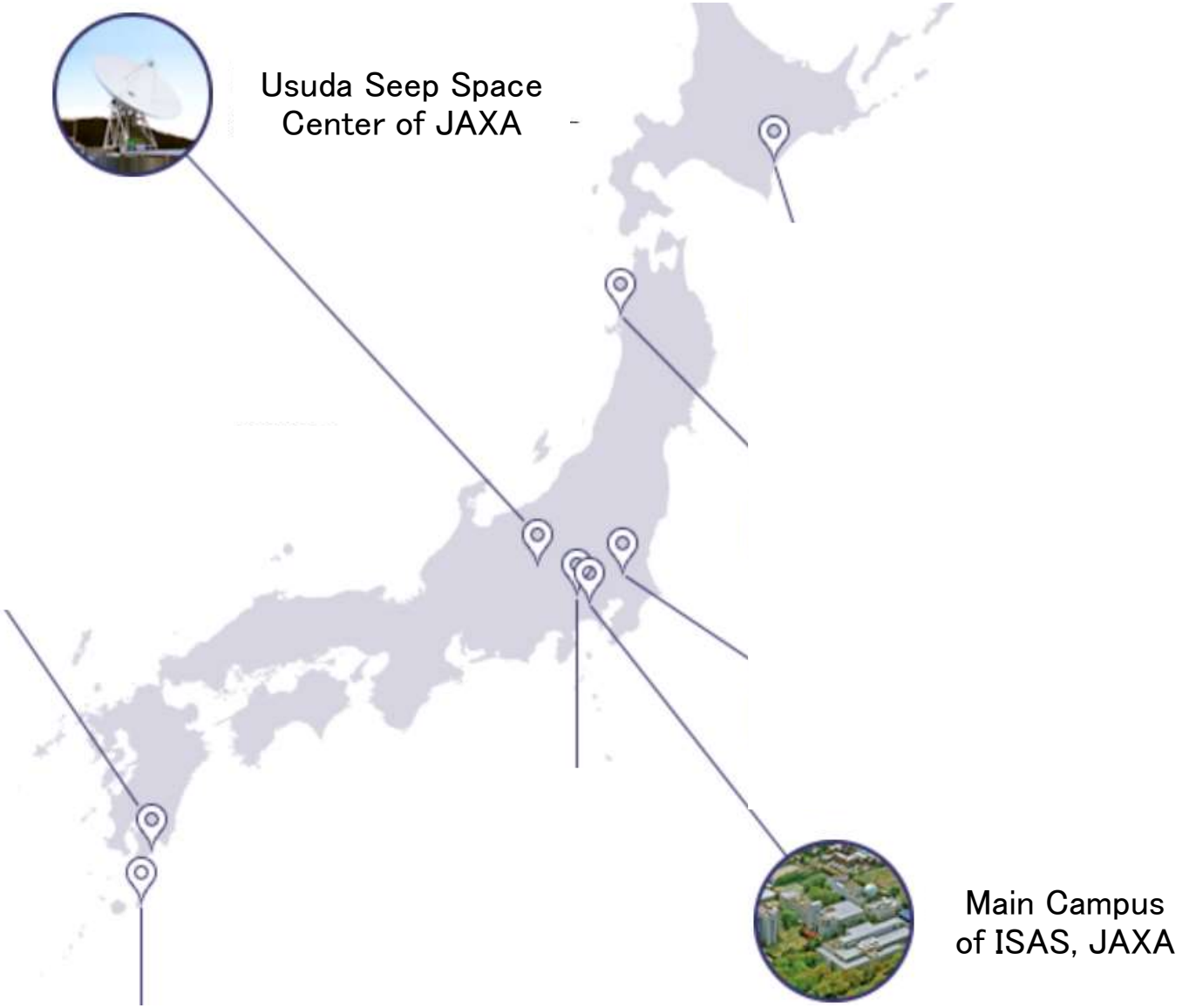
NEC

(Proposers: Tadashi Takano and Yashiro Murata)

Contents

- Total system configuration
- Operation issues
- Technological performances
- Correspondent antennas in foreign countries

Locations of Main Campus and Usuda Seep Space Center of ISAS, JAXA

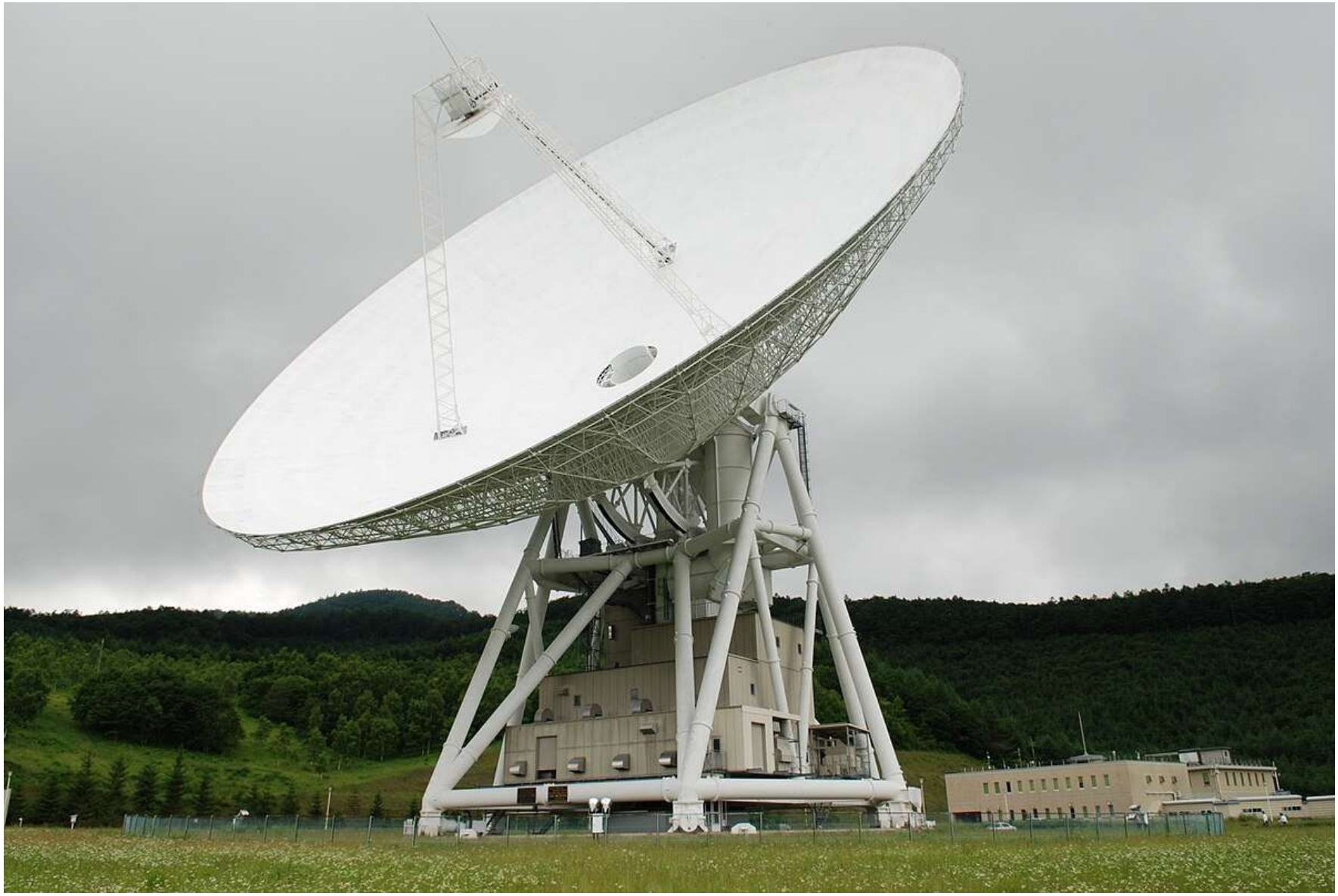


Institute of Space and Astronautical Science (ISAS), Main Campus at Sagamihara City

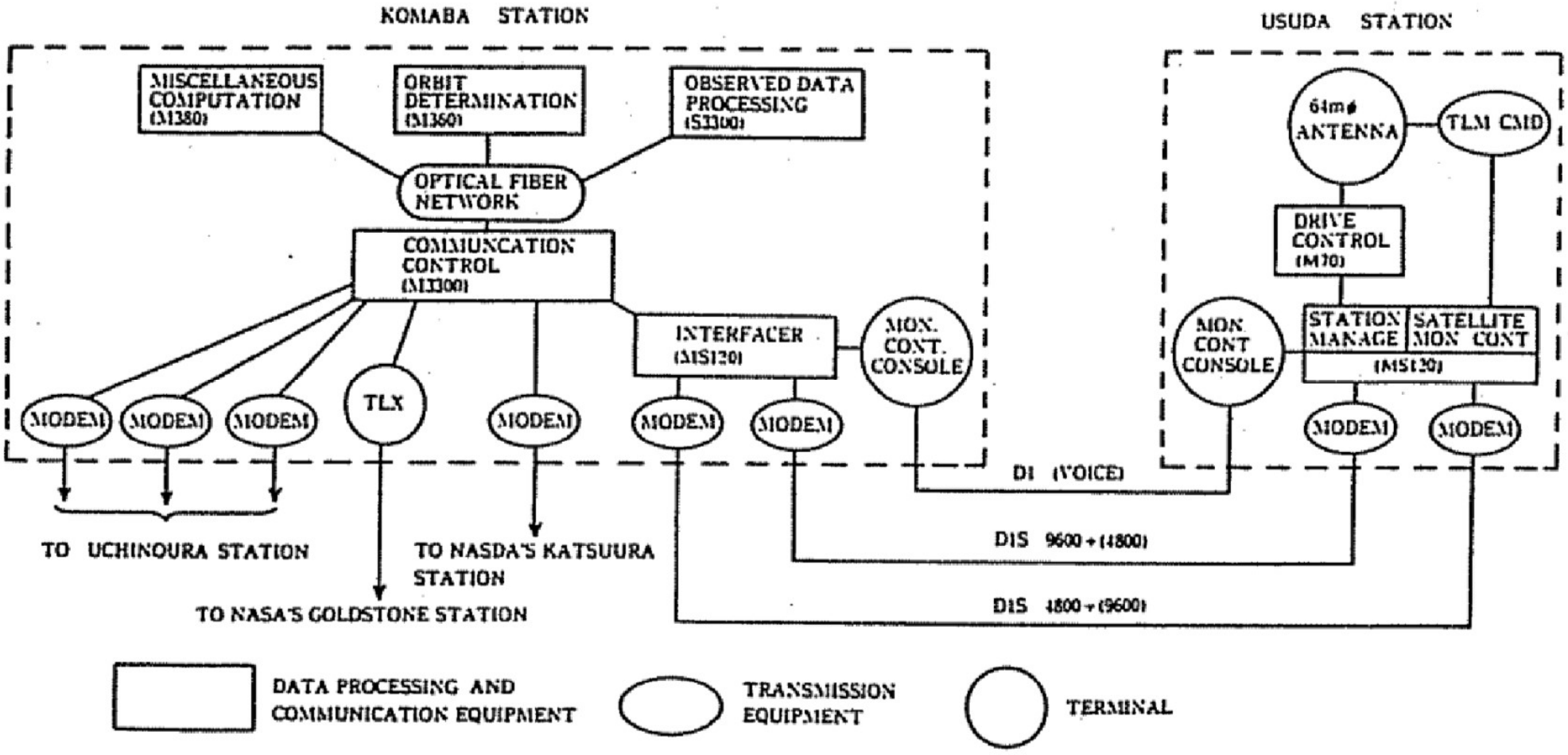
Space Science Exploration and Exchange Building

Usuda Seep Space Center at Saku City

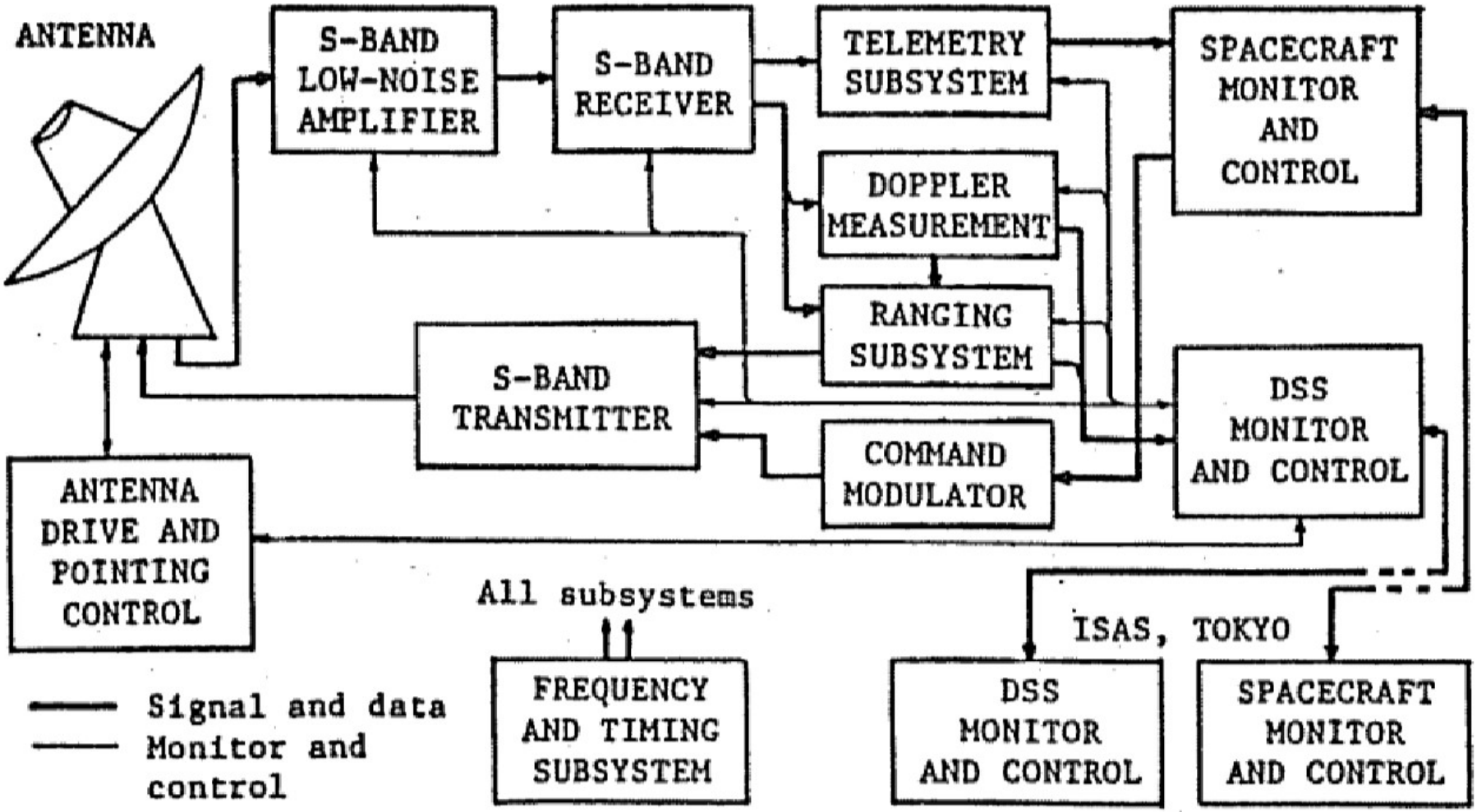
The main antenna with 64 m diameter and the operation building with two stories at the lower right.



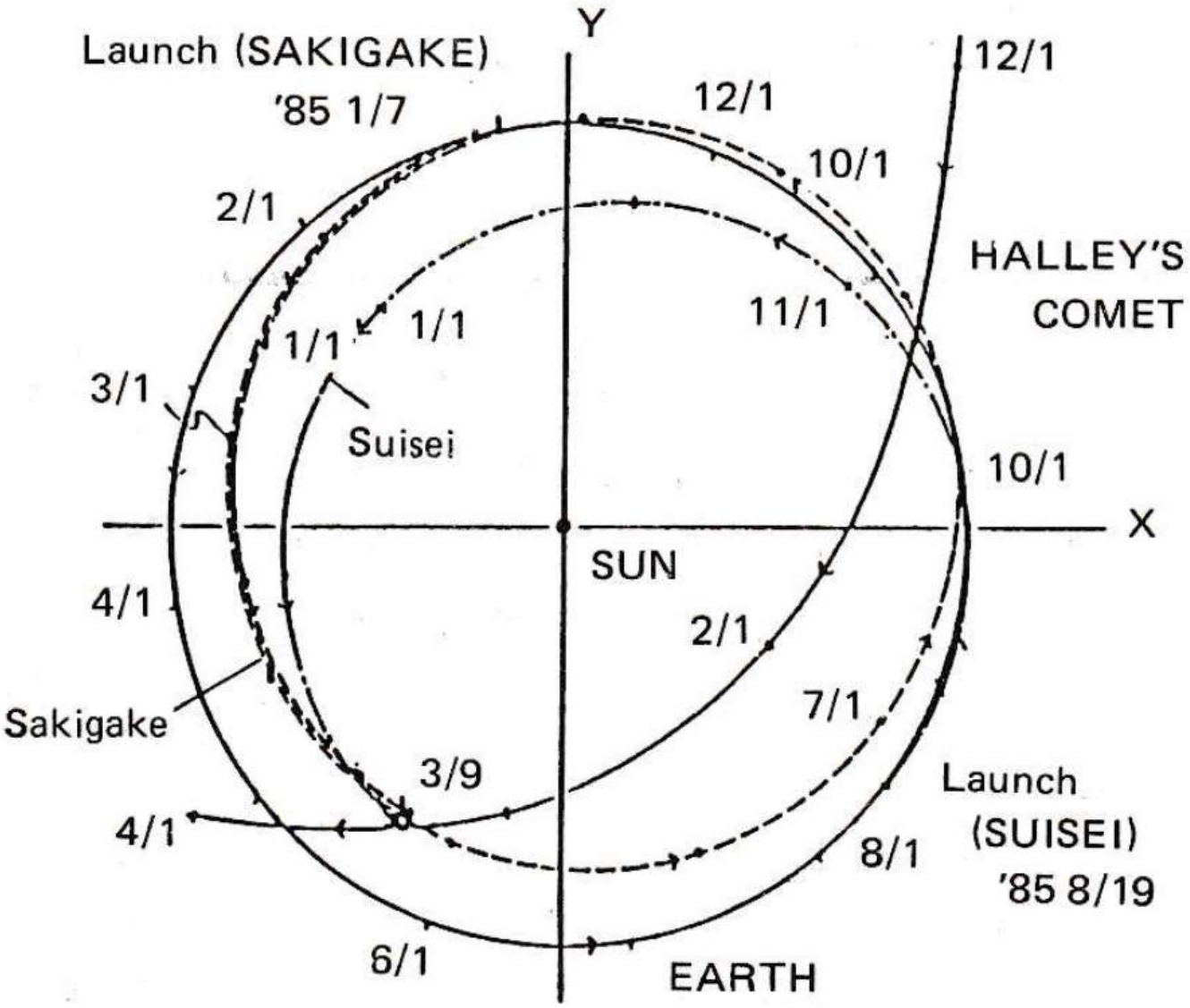
Functional diagram of the data communication and processing system
(T.Hayashi, et al., Jour. of Space Tech. and Science, 1987)



Functional block diagram of the Usuda Deep Space Center
(T.Hayashi, et al., Jour. of Space Tech. and Science, 1987)

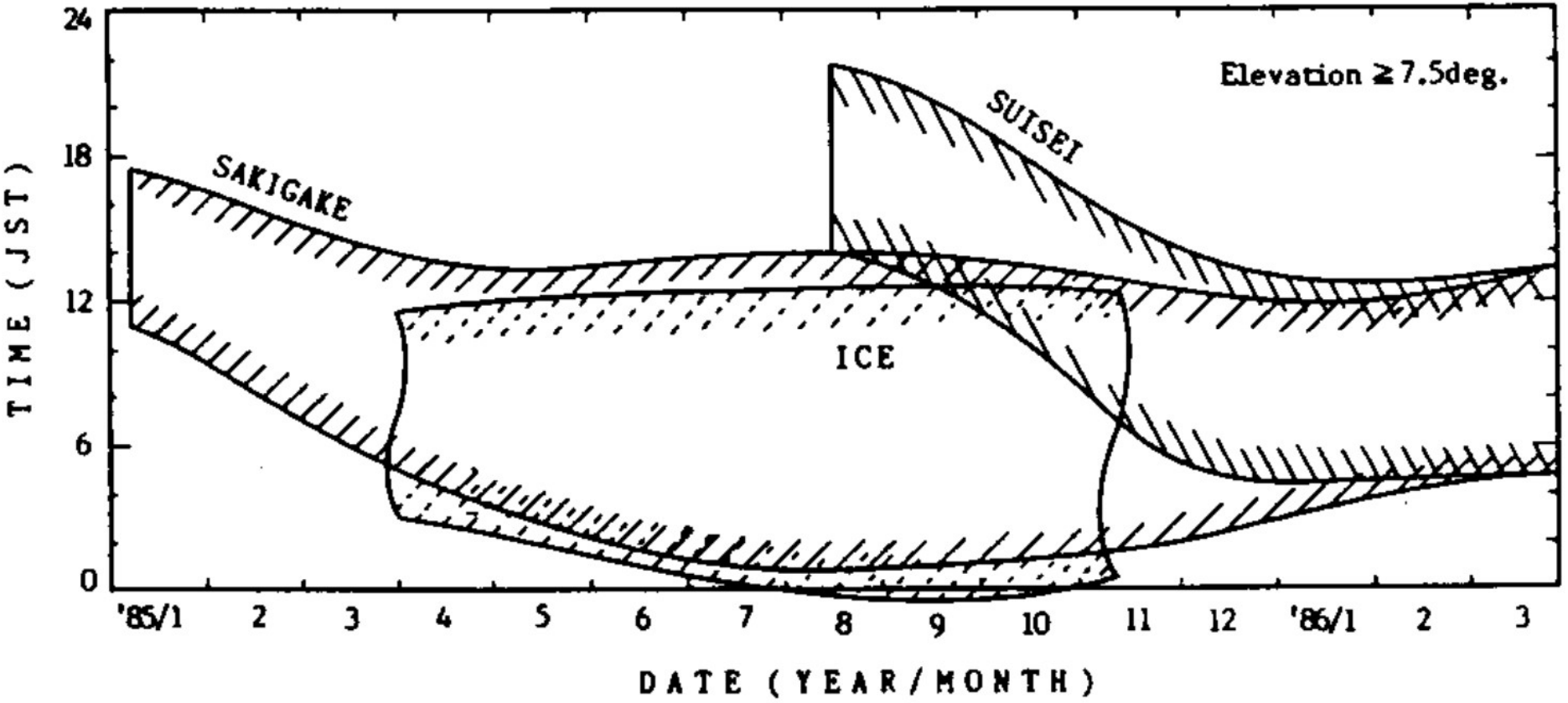


Helio-centric orbits of Halley's Comet and two deep space explorers SAKIGAKE and SUISEI in 1985.
(T.Hayashi, et al., Jour. of Space Tech. and Science, 1987.)

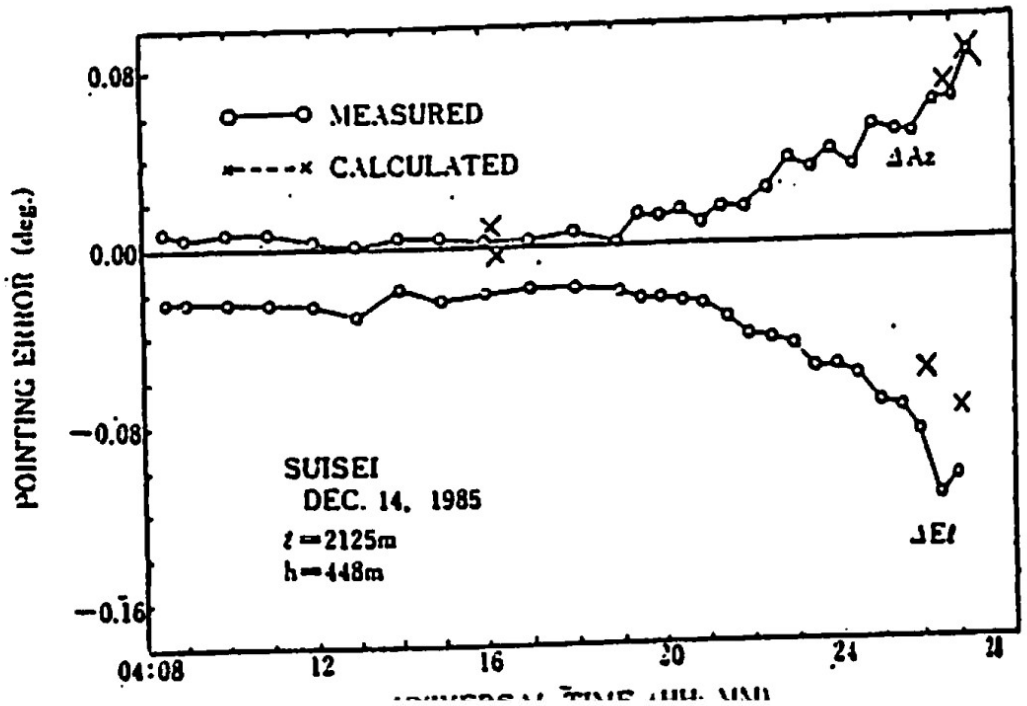


Visible window of 3 Halley‘s comet explorers from UDSC SAKIGAKE and RUISEI of Japan, and ICE of USA (T.Hayashi et al., Proceedings of the IEEE, 1994)

(1994 Japanese DS station)

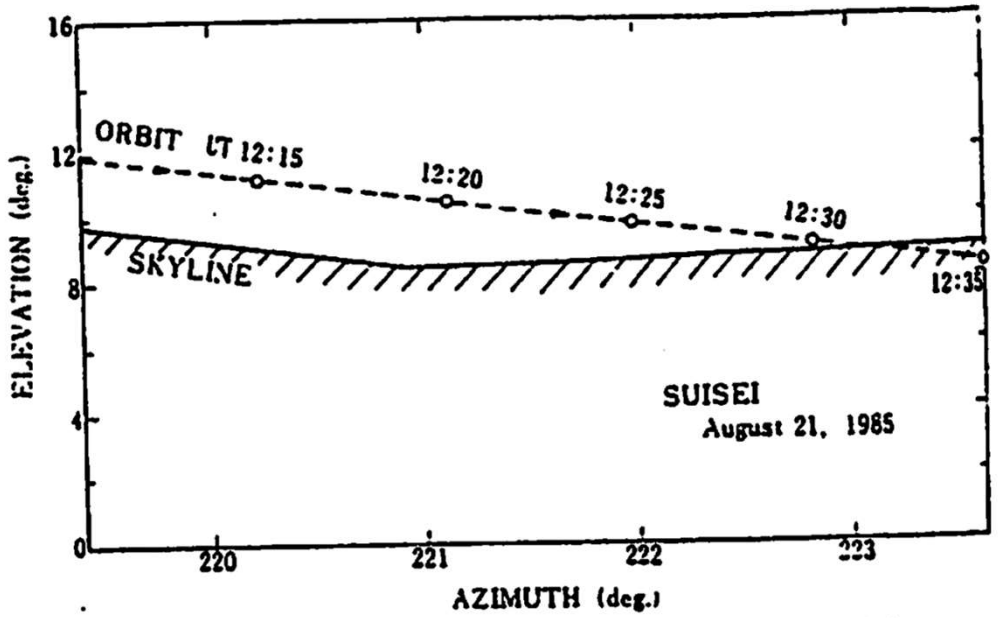


Strange behavior of the antenna at Loss-Of-Signal (LOS)



(T.Hayashi et al., MONTECH '86 IEEE, Conf. on Antennas and Communications)

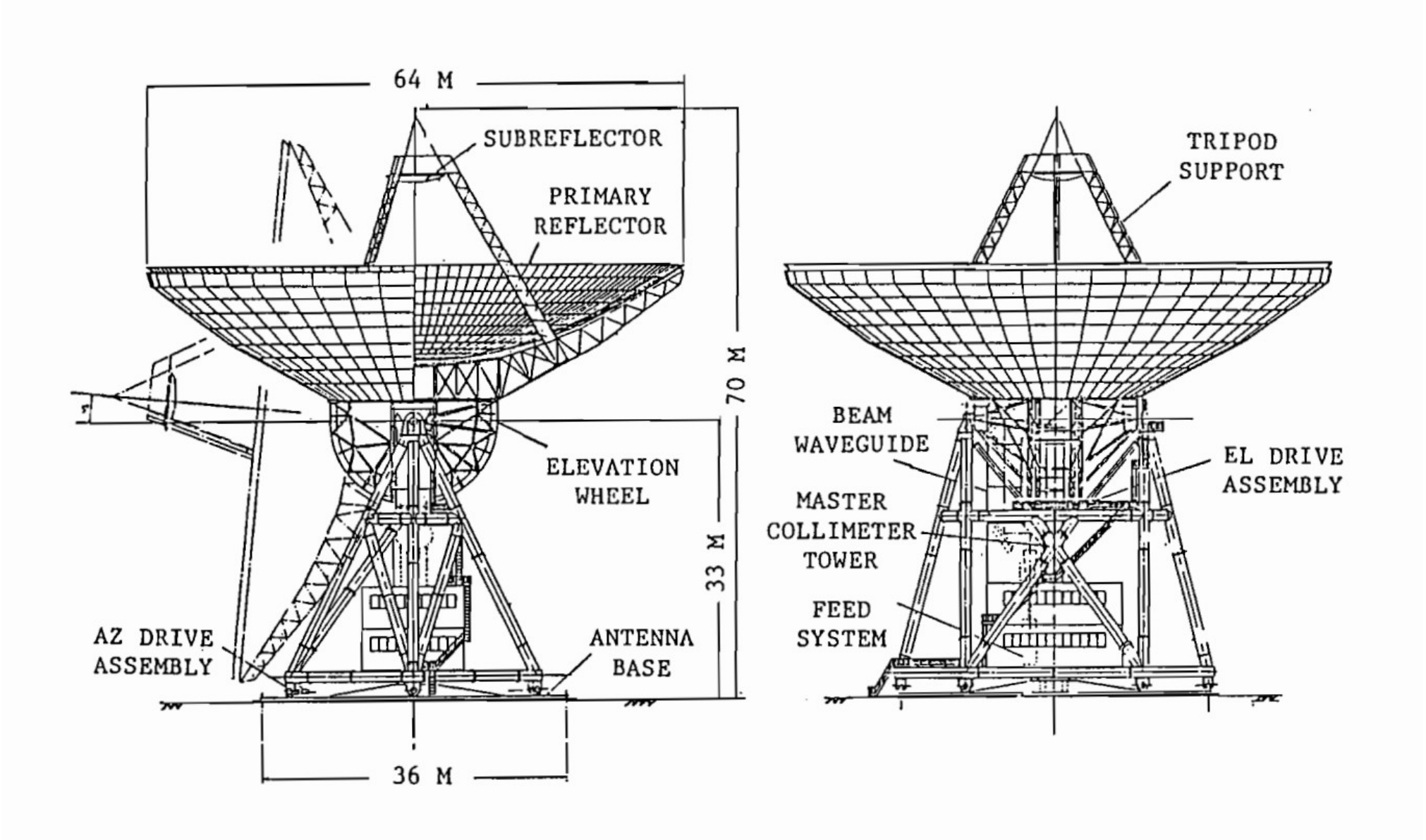
Antenna pointing error at LOS



The orbit of the spacecraft and the nearby skyline at LOS

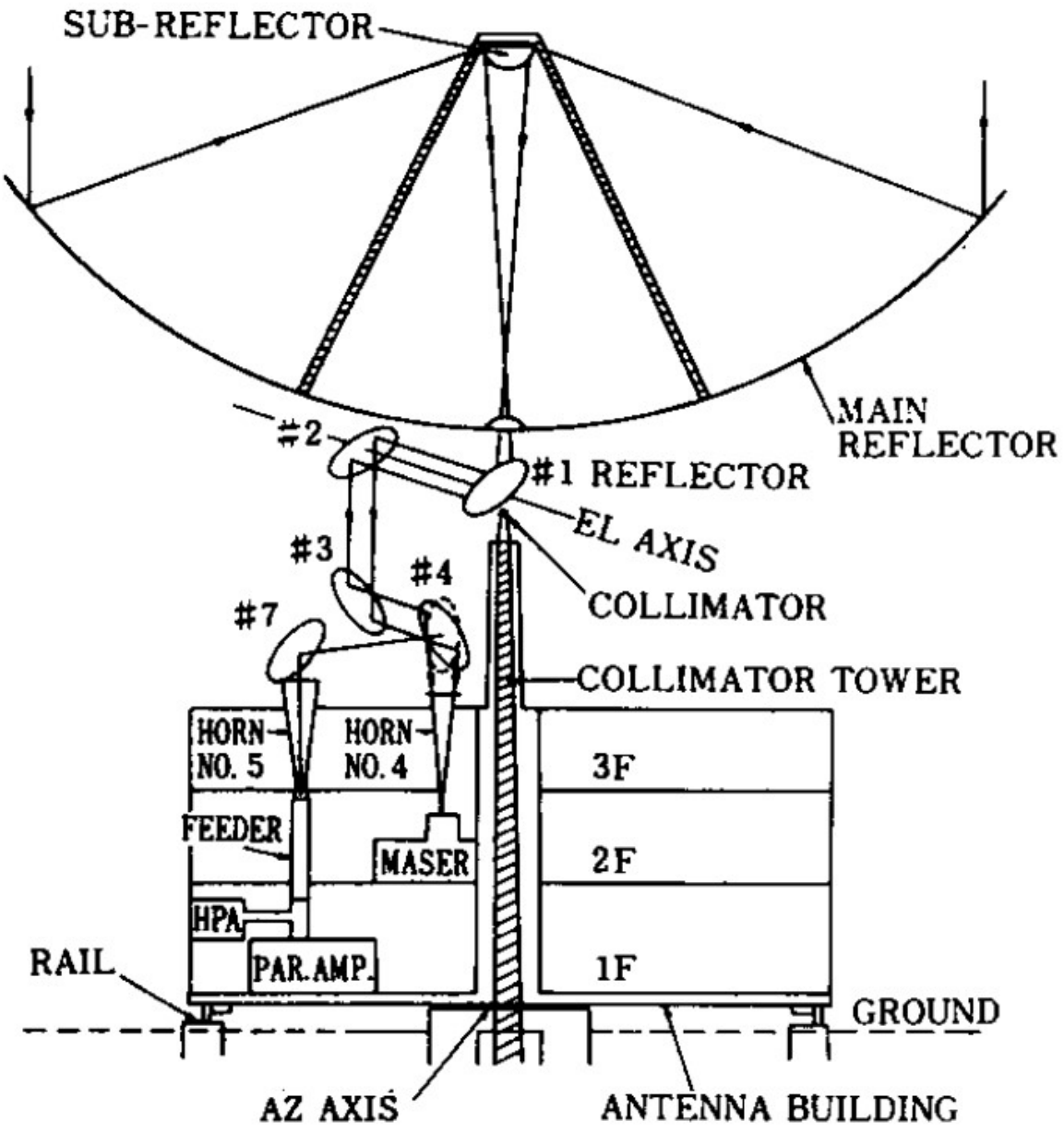
Structure of 64 m antenna

(T.Nomura et al., Transaction of IECE, 1986)



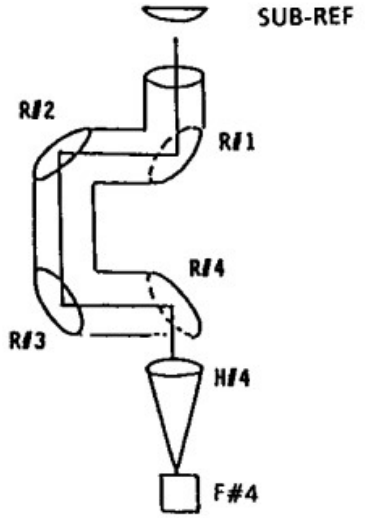
Antenna and electronics in the antenna building

(T.Hayashi et al., Proceedings of the IEEE, 1994)

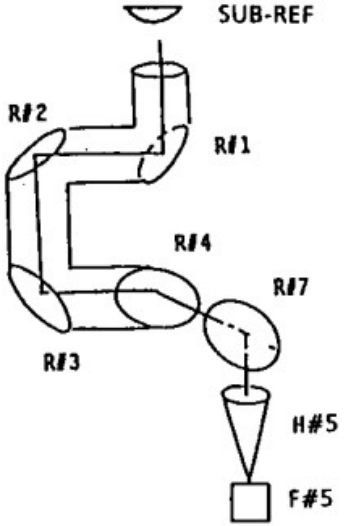


Beam-waveguide and feed assembly configurations with great versatility on frequencies and applications

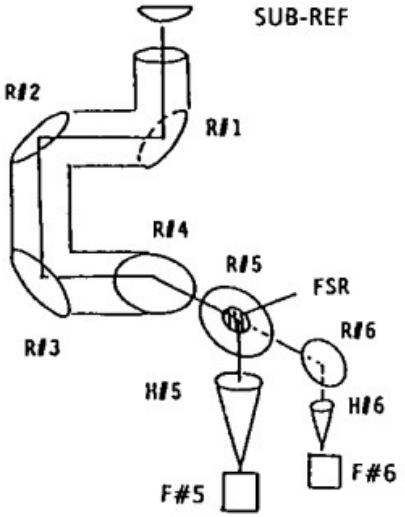
(T.Hayashi et al., Proceedings of the IEEE, 1994)



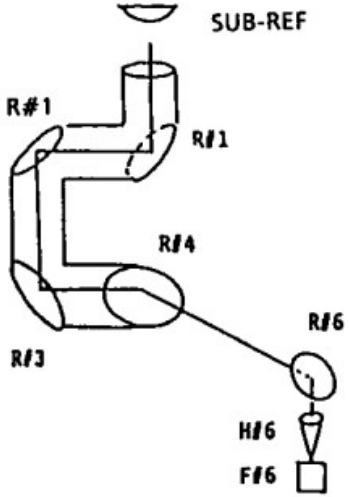
(a)



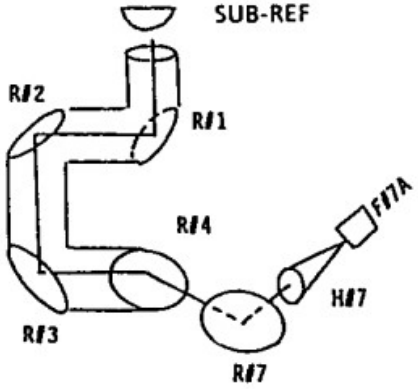
(b)



(c)



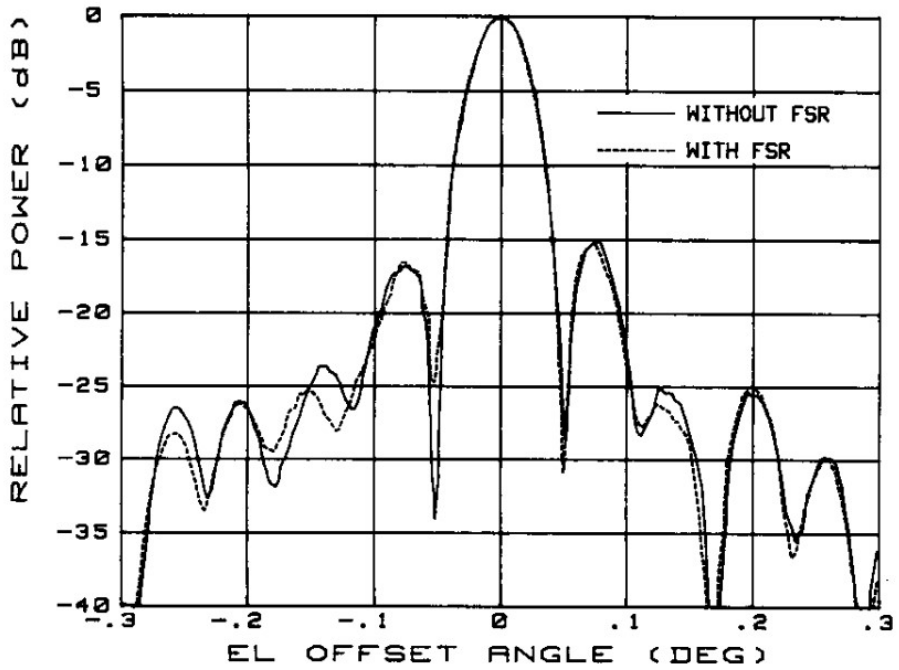
(d)



(e)

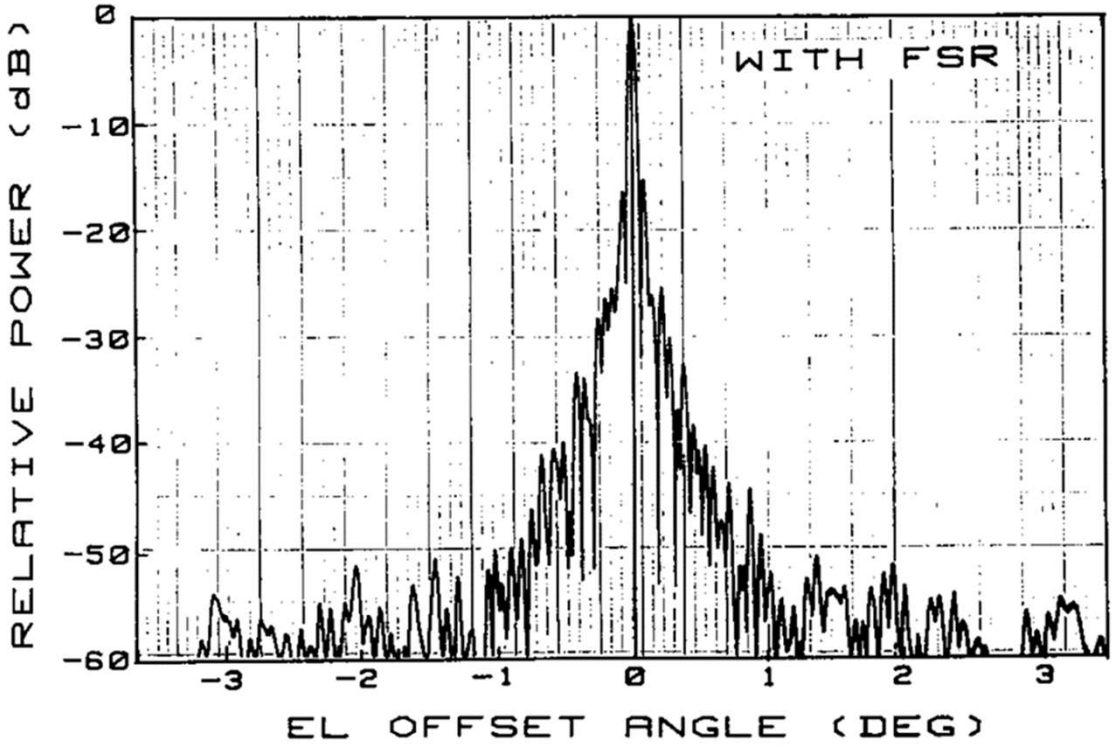
Note

R#1	:	First reflector (Plane)
R#2	:	Second reflector (Ellipsoid)
R#3	:	Third reflector (Ellipsoid)
R#4	:	4th reflector (Plane, rotatable)
R#5	:	5th reflector (Hyperboloid, FSR)
R#6	:	6th reflector (Ellipsoid)
R#7	:	7th reflector (Hyperboloid, rotatable)
FSR	:	Frequency Selective Reflector
H#4	:	Corrugated horn for S/X-band
H#5	:	Corrugated horn for S-band
H#6	:	Corrugated horn for X-band
H#7	:	Conical horn
F#4	:	Feed assembly for RX in S- or X-band
F#5	:	Feed assembly for TX/RX in S-band
F#6	:	Feed assembly for RX in S-band
F#7	:	Feed assembly with dual-mode excitor



Radiation pattern
in Configuration #3, El-plane, and co-polarization.
(T.Hayashi et al., Proceedings of the IEEE, 1994)

Near-axis radiation pattern



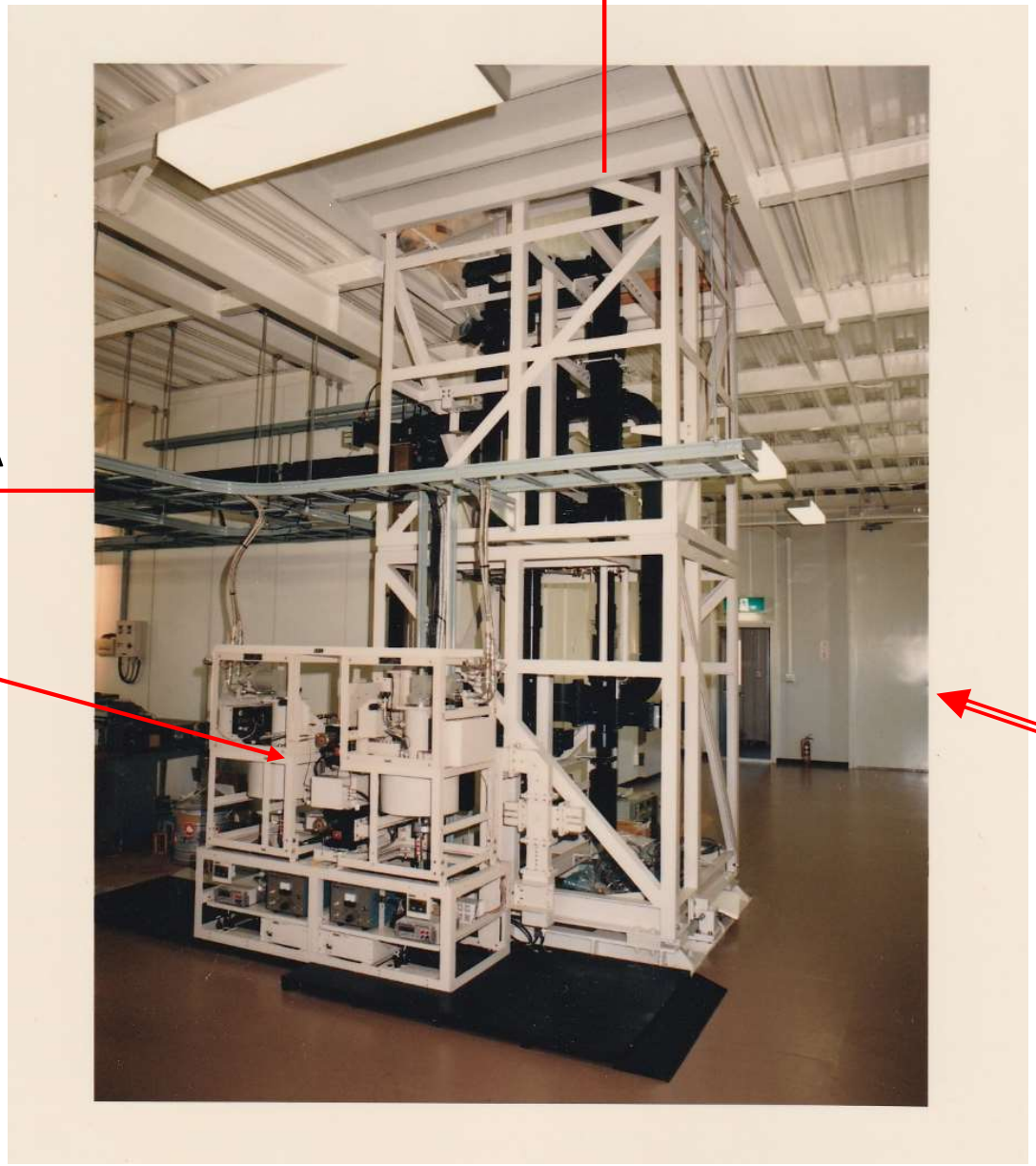
Wide-angle radiation pattern

Branching circuit for the antenna horn, HPA and LNA

to the antenna

to HPA

LNAs



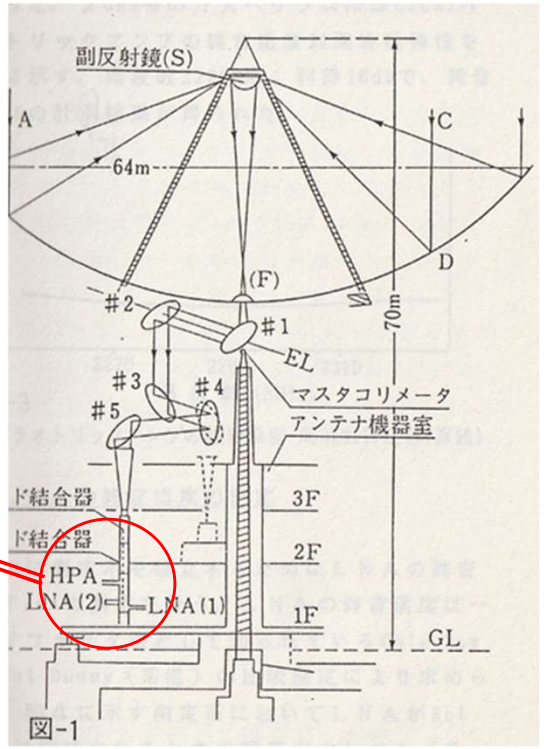
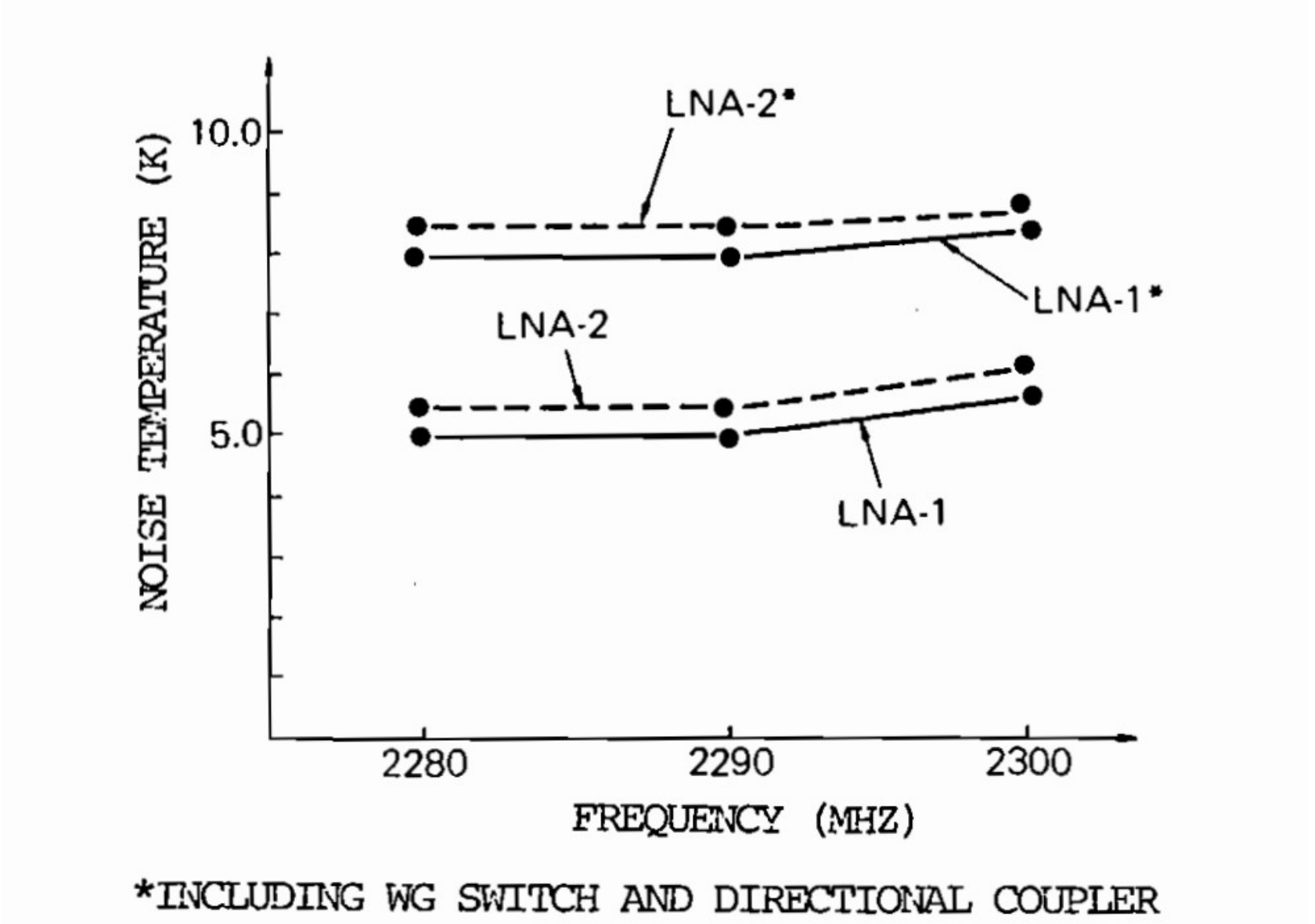


図-1

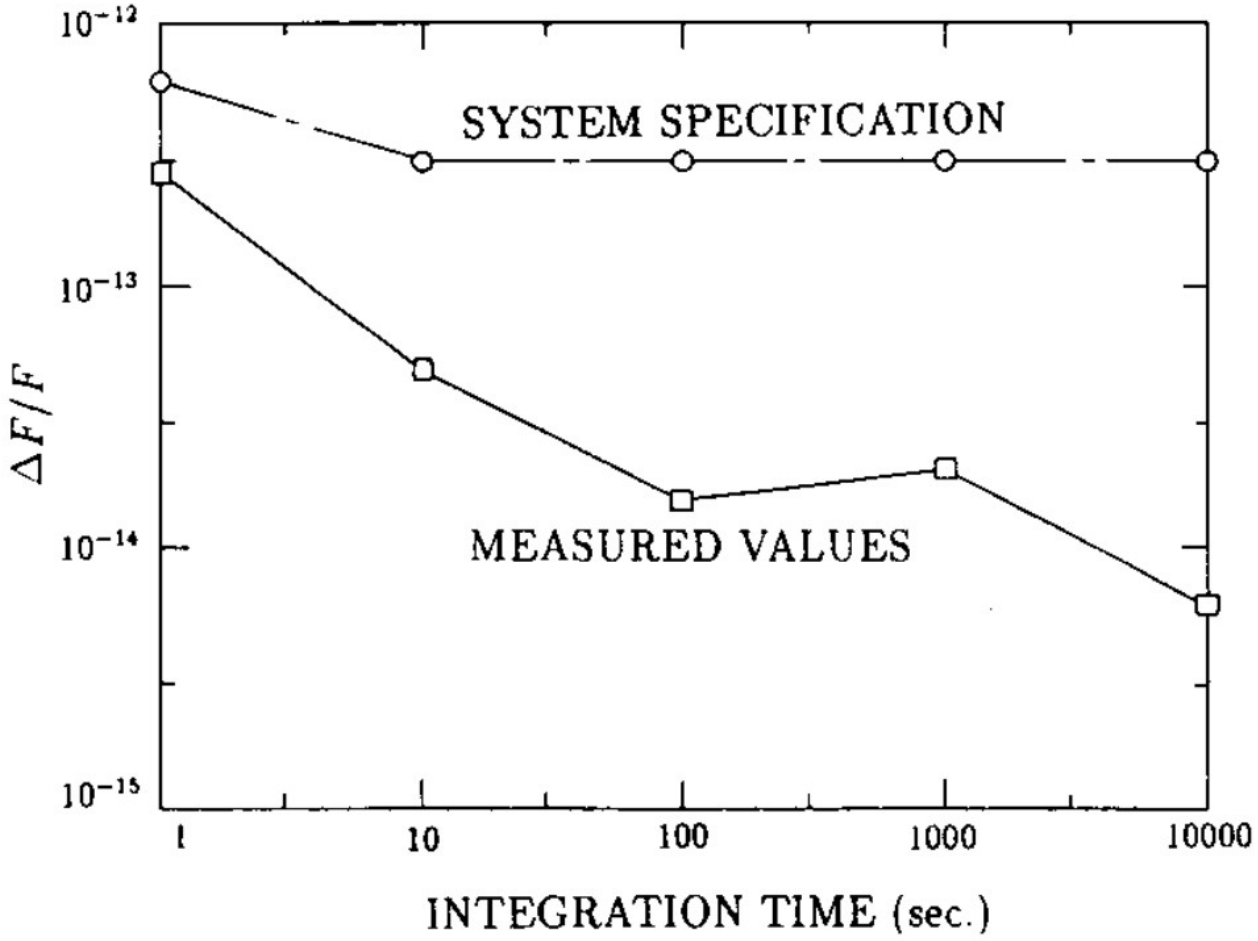
Measured noise temperature of the low noise amplifiers

(T.Nomura et al., Transaction of IECE, 1986)



Frequency stability of the hydrogen maser

(T.Hayashi et al., Proceedings of the IEEE, 1994)



Item		Value	Note
Explorer	Output power	37.4 dBm	5.5W
	Antenna gain	23.1 dB	High gain antenna
	Pointing error	-0.2 dB	Less than 1.5 deg
	Feeder loss	(-)3.2 dB	
Space	Free space loss	(-)263.8 dB	1.6 x 10^8 km
	Propagation loss	(-)0.3 dB	Rain, polarization loss
Earthstation	Antenn gain	62.4 dB	Diameter 64m
	Pointing error	-0.2 dB	
	Feeder loss	(-)0.3 dB	
(subtotal)Receivedpower		-145.1 dBm	
Modulation loss		(-)2.1 dB	Modulation index = 0.9 rad.
Demodulation loss		(-)1.6 dB	PSK demodulation, synchro., distortion, circuit
Data rate		18.1 dBHz	64 b/s
Noise power density		-182.9 dBm/Hz	antenna at E_l=20deg 18K, group filter 10K, LNA 9K
(subtotal)E_b/N_o		16.0 dB	
Coding gain		5.1 dB	BER= 10^{-5} Viterbi decode
Required E_b/N_o		9.6dB	BER=10^{-5}, BPSK, Synchro detection
(total)Bargin		11.5 dB	

Communication link budget between Halley's explorer and UDSC
* telemetry
* at the Halley's comet encounter

T.Nomura,et al., "Telecommunications System for Halley's Comet Exploration", Transaction of IECE, vol.J69-B, no.11, pp.1267-1275, November, 1986 (in Japanese).

The beam-waveguide antenna with 35 m diameter of NASA after construction in 1990

From Descanso_Mono4_web_Imbriale "Large Antennas of the Deep Space Network"

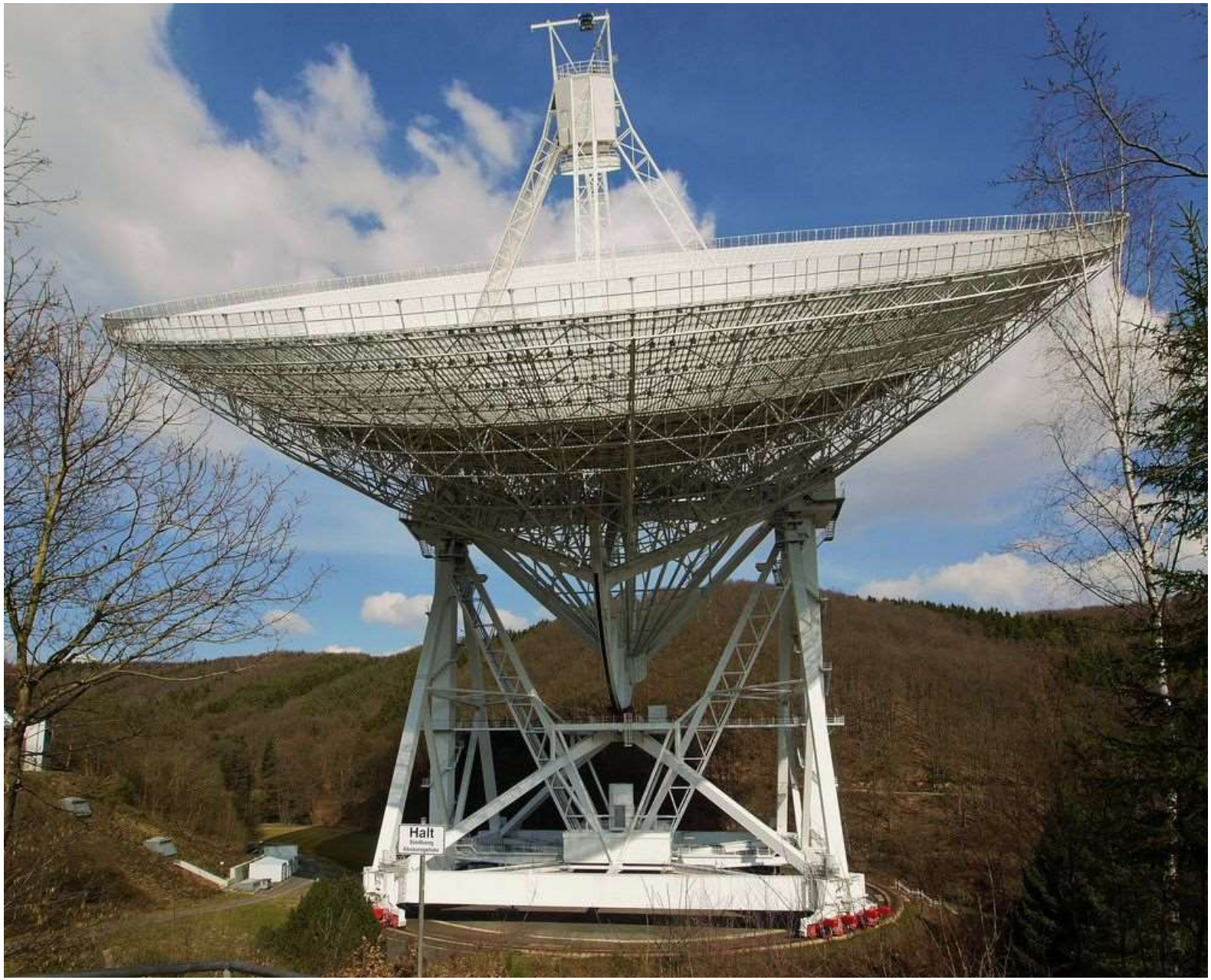
The 70-meter DSS-14 antenna at Goldstone, USA.

The DSS-43 radio antenna of 70m diameter, located at the Canberra DSC Complex, Australia.

IEEE Spectrum, July 2024.

Effelsberg radio telescope of 100m diameter, Germany

Radioteleskop Effelsberg II Foto & Bild | reportage dokumentation, wissenschaft, technik Bilder auf fotocommunity



FAST radio telescope of 500m diameter, China.

https://en.wikipedia.org/wiki/Pingtang_County#/media/File:FAST_Radio_Telescope_(captured_from_video).jpg

The