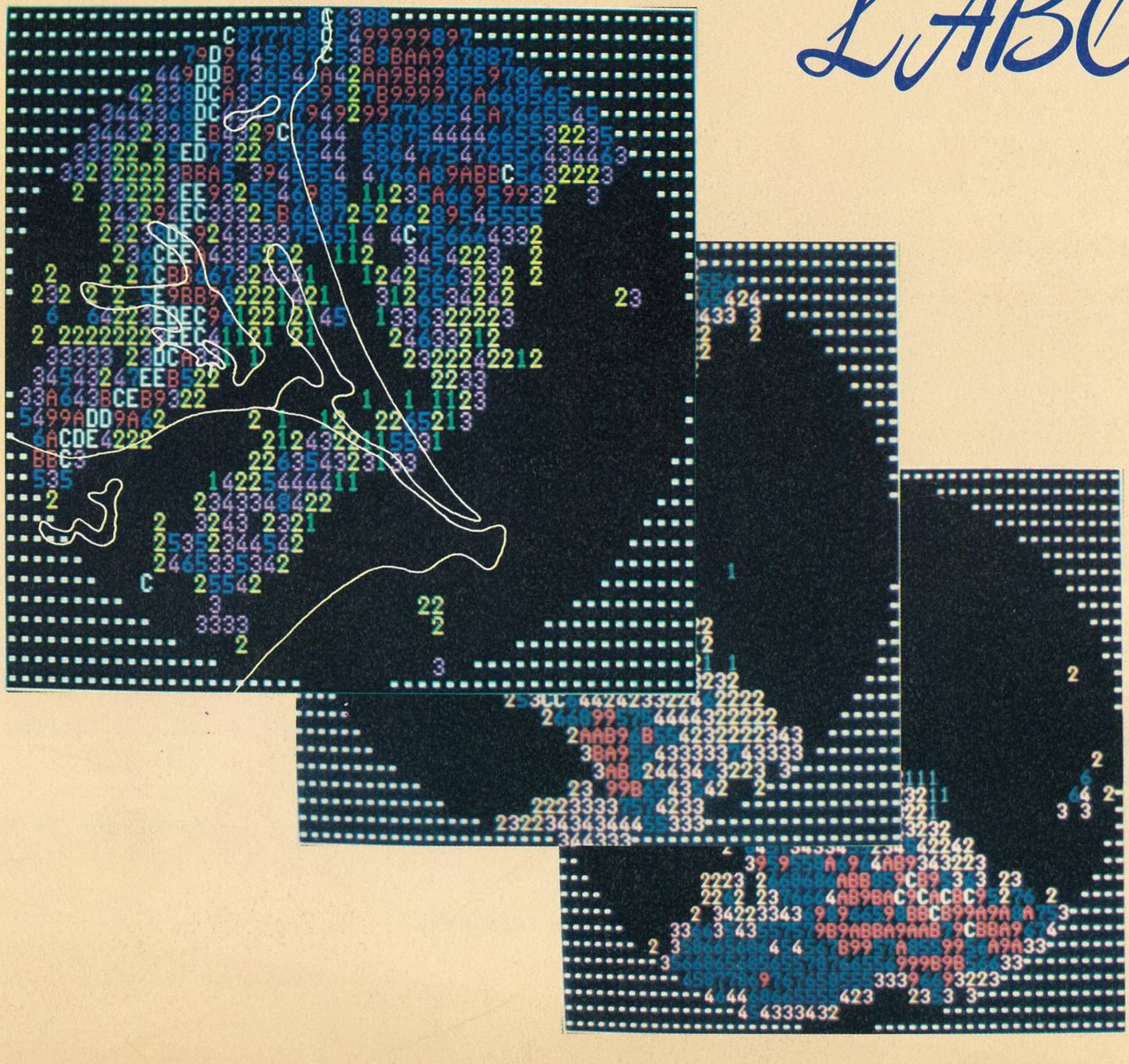
RADIO RESEARCH LABORATORIES



1980

BIRD'S–EYE VIEW OF THE RADIO RESEARCH LABORATORIES

Photographs on the front cover show rainfall distribution patterns at some altitudes (50km radius, centered at Kashima Branch). Numeric display over 3 indicates heavy rainfall (more than 8mm/hour). These pictures are obtained by data analysis of rain radar (C-band) having the external view on the back cover.

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BUDGET .... 5.6 BILLION YEN (FY 1979)

REGULAR PERSONNEL 471

CONTENTS

MISSION OF THE RADIO RESEARCH LABORATORIES

It is only less than a century since the mankind set about making use of radio waves. During those years there has been a remarkable progress in the field of radio science and its applications. Since radio waves are utilized in various fields, such as telecommunications, broadcasting, remote control, remote sensing, etc., they are indispensable for the formation of modern society.

The Radio Research Laboratories (RRL) was established in 1952 as an auxiliary organization attached to the Ministry of Posts and Telecommunications. The mission of the Radio Research Laboratories is to conduct researches aiming at effective utilization of radio waves that are limited resources for the welfare of mankind. The major research programs are classified into the following fields: (1) Space communications, (2) Space and atmospheric sciences, (3) Information processing and communication systems, (4) Frequency standards and (5) Efficient use of frequency spectra.

Space development cannot be conceived without radio waves. Propagation experiments have been carried out by use of Engineering Test Satellite Type II (ETS-II), the first Japanese geostationary satellite. In response to the increase and diversification of demand for future domestic communications and broadcasting, the Ministry of Posts and Telecommunications already launched the Medium-Capacity Communications Satellite for Experimental Purposes (CS) and the Medium-Scale Broadcasting Satellite for Experimental Purposes (BSE) respectively. Various kinds of experiments are being performed by use of these satellites and the main earth stations at the Kashima Branch of the Radio Research Laboratories, in cooperation with the National Space Development Agency of Japan (NASDA), Nippon Telegraph and Telephone Public Corporation (NTT) and Japan Broadcasting Corporation (NHK). Furthermore, the research and development of a satellite system for communications between ground stations and aeronautical or maritime stations are in progress, and the multibeam satellite antenna system is under investigation.

An important role of radio waves in monitoring the Earth's environment cannot also be overlooked. Ground-based observations of the ionosphere have been carried out for many years at five Radio Wave Observatories and at Syowa station in Antarctica, taking part in the worldwide observation network. The global mappings of the ionospheric critical frequency and the thunderstorm activity are being made by means of equipments on board the Ionosphere Sounding Satellite –b (ISS-b). The Radio Research Laboratories engages not only in the monitoring of the sun and cosmic space, but also to meet the requirements of the times, in the technical development of remote sensing of various phenomena occurring near the Earth's surface by using radio, optical and acoustic waves. As an application of space science technology, the very long baseline interferometry (VLBI) method has recently been attracting a good deal of attention, especially with regard to the measurement of the precise location of radio stars or artificial satellites, the study of polar motion, and geodetic applications.

In the field of information processing and communication systems, the experiment of a computer network is going to be carried out by use of the CS in the latter half of its life span. A speech processing system so-called SPAC (Speech Processing system by use of Auto-Correlation function) has been developed, aiming at the reduction of superposed noise, the band-compression and -expansion of speech signals. For the purpose of performing automatic processing of hand-written Chinese characters, the stroke extraction method is under investigation.

The Radio Research Laboratories has been developing Hydrogen maser type atomic standard since 1965 and Caesium laboratory type standard since 1976, in order to improve the accuracy of the national standard of frequency and atomic time scale. The international comparison of atomic time scales has also been made via Loran-C, VLF and satellites. As one of promising methods for time and frequency dissemination, the experiment using TV signals from BSE was conducted.

As for the frequency resources which are not yet used, research on higher frequency bands above 40 GHz is earnestly required, in consideration of the expected increase in future communications demands. In order to utilize effectively the frequency spectrum, it is also necessary to re-examine the frequency bands in current use.

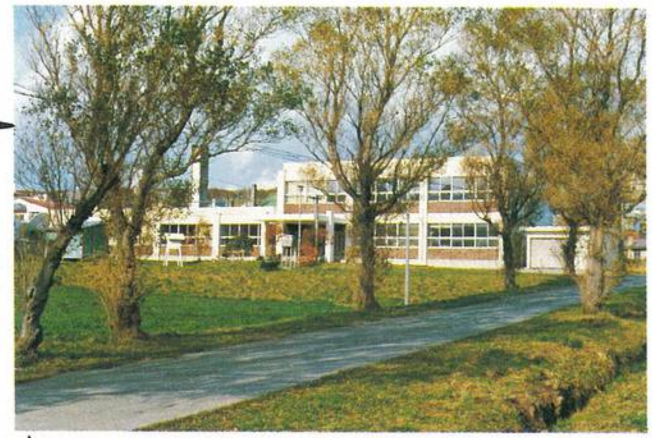
In addition to the above-mentioned research works, the Radio Research Laboratories is offering the regular services, such as the prediction and disturbance warning of ionospheric radio propagation conditions, dissemination of standard frequencies and time signals, and type approval tests, performance tests and calibration of radio equipments. Such services are essential for the promotion of effective utilization of radio waves.

Director General Mr. Yoshitaka Kurihara

LOCATION OF THE RADIO RESEARCH LABORATORIES

▲
HEADQUARTERS
35°42.4′N 139°29.3′E
2-1, Nukui-Kitamachi 4-chome, Koganei-shi,
TOKYO 184 JAPAN
TEL. 0423-21-1211 TLX. 2832611 DEMPAJ
Cable DEMPA KOKUBUNJI TOKYO

▲
AKITA RADIO WAVE OBSERVATORY
39°43.5′N 140°08.2′E
6-1, Tegata-Sumiyoshi-cho, Akita-shi, AKITA
010 JAPAN
TEL. 0188-32-3767



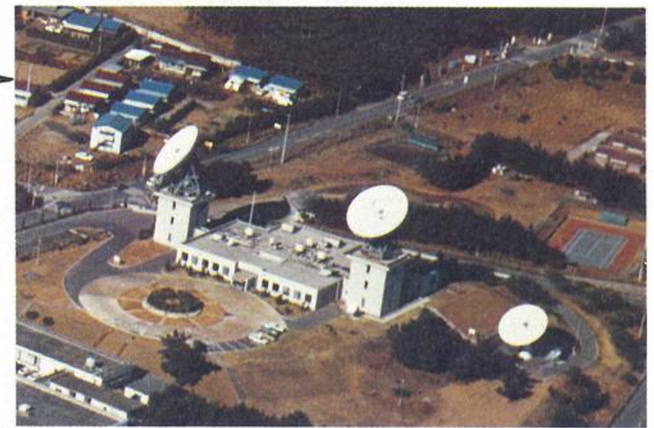
▲
WAKKANAI RADIO WAVE OBSERVATORY
45°23.6′N 141°41.1′E
3-20, Midori-cho 2-chome, Wakkanai-shi,
HOKKAIDO 079 JAPAN
TEL. 01622-3-3386

◀ YAMAGAWA RADIO WAVE OBSERVATORY
31°12.1′N 130°37.1′E
2719, Narikawa, Yamagawa-machi
Ibusuki-gun, KAGOSHIMA
891-05 JAPAN
TEL. 09933-4-0077

▲
HIRAISO BRANCH
36°22.0′N 140°37.5′E
3601, Isozaki-machi, Nakaminato-shi,
IBARAKI 311-12 JAPAN
TEL. 02926-5-7121

▲
OKINAWA RADIO WAVE OBSERVATORY
26°16.9′N 127°48.4′E
829-3, Daigusukubaru, Aza-Kuba,
Nakagusuku-son, Nakagami-gun, OKINAWA
901-24 JAPAN
TEL. 09889-5-2045

▲
INUBO RADIO WAVE OBSERVATORY
35°42.2′N 140°51.5′E
9961, Tennodai, Choshi-shi, CHIBA
288 JAPAN
TEL. 0479-22-0871



▲
KASHIMA BRANCH
35°57.2′N 140°40.0′E
Hirai, Kashima-machi
Kashima-gun, IBARAKI
314 JAPAN
TEL. 02998-2-1211
TLX. 3658901 COMKASJ

ORGANIZATION OF THE RADIO RESEARCH LABORATORIES

Director General

Deputy Director General

Associate Director General

HEADQUARTERS

Administrative Division
- General Affairs Section
- Accounts Section

Planning and Support Division
- Project Support Section
- Technical Service Section

Technical Consulting Division
- International Radio Affairs Research Section
- Frequency Utilization Research Section
- Radio Application Research Section
- Communication System Advisory Section

Information Processing Division
- Information Processing Research Section
- Computer Applications Research Section
- Computer System Research and Service Section
- Speech Processing Research Section

Radio Wave Division
- Radio Propagation Research Section
- Ionospheric Radio Prediction Section
- Space Physics Section
- Millimeter Wave Propagation Research Section
- Satellite Data Research Section

Satellite Communications Division
- Fixed-Satellite Communications Research Section
- Satellite Broadcasting Research Section
- Mobile-Satellite Communications Research Section

Satellite Remote Sensing Division
- Terrestrial Environment Research Section
- Ionosphere Research Section

Communication System and Apparatus Division
- Communication System Research Section
- System Performance Research Section
- Standards and Measurements Research Section
- Applied Radio Physics Section
- Marine Communication Research Section
- Communication Apparatus Section

Frequency Standard Division
- Atomic Standards Research Section
- Standard Frequency and Time Research Section
- Standard Frequency and Time Dissemination Section

Special Research Section for Space Physics
Special Research Section for Atmospheric Radio Science
Special Research Section for Radio Physics

REGIONAL BRANCHES AND OBSERVATORIES

Kashima Branch
- Administration Section
- Satellite Control Section
- Space Communication Research Section
- Space Communication Applications Section
- Space Research Section

Hiraiso Branch
- Upper Atmosphere Research Section
- Solar Radio Research Section

Wakkanai Radio Wave Observatory
Akita Radio Wave Observatory
Inubo Radio Wave Observatory
Yamagawa Radio Wave Observatory
Okinawa Radio Wave Observatory

INTER-DIVISIONAL GROUPS FOR:

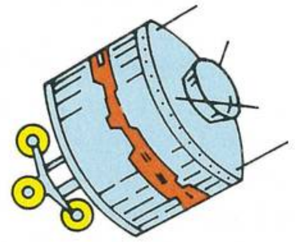
- C.C.I.R.
- CS Project
- BSE Project
- Millimeter Wave Satellite Communications System Research
- ISS Project
- VLBI System Development
- Observations in Antarctica
- Computer System Operation
- Space Development Programs Planning
- Space Research and Development Coordination

ETS-II ENGINEERING TEST SATELLITE TYPE II

ETS-II ("Kiku-2") was launched on February 23, 1977 from Tanegashima Space Center of NASDA, and positioned in geostationary orbit at 130°E longitude on March 5. ETS-II is the first geostationary satellite launched with an N-launch vehicle by NASDA. ETS-II carries a microwave beacon transmitter with three coherent frequencies of 1.7, 11.5 and 34.5 GHz, and a VHF telemetry transmitter.

RRL carried out propagation experiments with the microwave beacons for about one year beginning in April 1977, and also have been studying ionospheric effects on radio propagation by receiving the VHF signal.

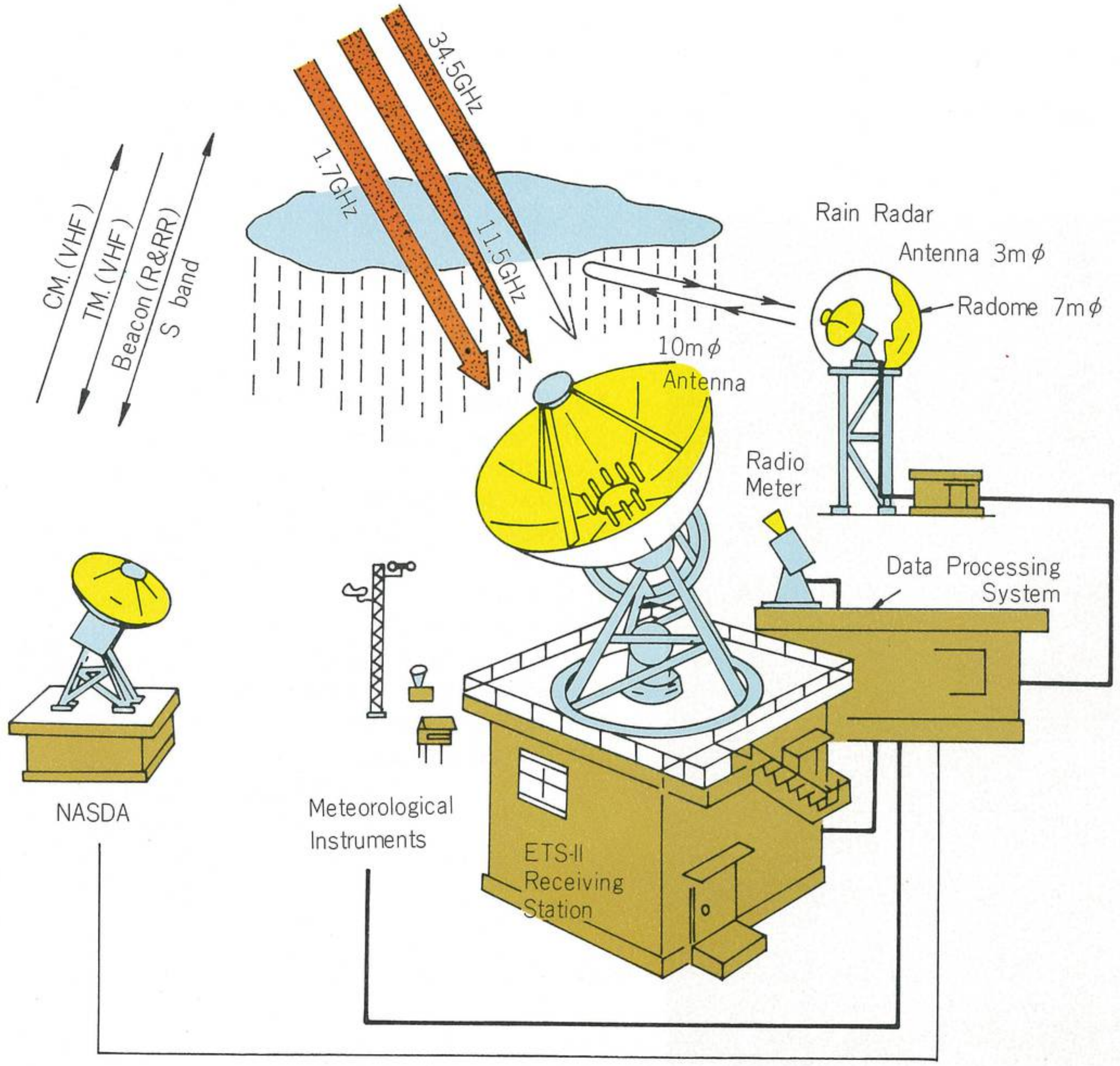
During the course of the experiments, various tropospheric and ionospheric phenomena occurred, including Japan's rainy season, thunder storms, typhoons, snow, hail, and geomagnetic storms.



ETS-II

OUTLINE OF ETS-II

Launch in Feb. 1977 by N-Rocket
130°E on geostationary orbit
130kg at the beginning of life
Cylindrical type with mechanically despun antennas
(D:1.4m, H:1.9m including antennas)
100W solar cell power source
VHF and S-band TT & C
Spin stabilization
Propagation experiment transmitter



Outline of ETS-II experiment system

BSE MEDIUM-SCALE BROADCASTING SATELLITE FOR EXPERIMENTAL PURPOSES

Japan's BSE satellite was launched on April 8, 1978 from the Eastern Test Range, Florida of U.S.A. and was located at 110° E longitude in the geostationary orbit.

The experiments will be continued for at least three years in order to establish operational satellite broadcasting systems necessary for meeting various demands in future.

The ground facilities of the experiments are composed of the Main Transmit and Receive Station of RRL, the Transportable Transmit and Receive Station, the vehicle mounted type Transportable Transmit and Receive Station, ten Receive-only Stations and many Simple Receive Equipments of NHK which are distributed throughout Japan, the Tracking and Control Center and the two Tracking and Control Stations of NASDA.

The satellite antenna was so designed as to have a suitable radiation pattern for providing high quality color TV broadcasting services to the whole Japan territory.

BSE

OUTLINE OF BSE

Launch in Apr. 1978 by Delta 2914
110° E on geostationary orbit
3 year life
350kg at the beginning of life
Rectangular solid with deployable solar array panel (W: 1.3m, H:3.1m, L:9m including deployed solar array panel)
780W solar panel power source
S-band and K-band TT & C
Zero-momentum 3-axis stabilization
Two color TV channels
100 Watts/channel

Main Transmit and Receive Station for BSE (left)

CS MEDIUM-CAPACITY COMMUNICATIONS SATELLITE FOR EXPERIMENTAL PURPOSES

The CS was successfully launched on Dec. 15, 1977 from the ETR of U.S.A. and put on a stationary orbit position of 135° E longitude. RRL has been conducting various communication experiments using this satellite in cooperation with NTT since May 15, 1978.

The experiments will be continued for at least three years in order to secure technical data and system operation experience necessary for establishing future operational domestic satellite communication systems in Japan.

RRL's ground facilities of the CS project are composed of the Main Fixed Earth Station at Kashima, SCPC small terminal at Yamagawa and field strength measuring terminals at Yamagawa and Wakkanai.

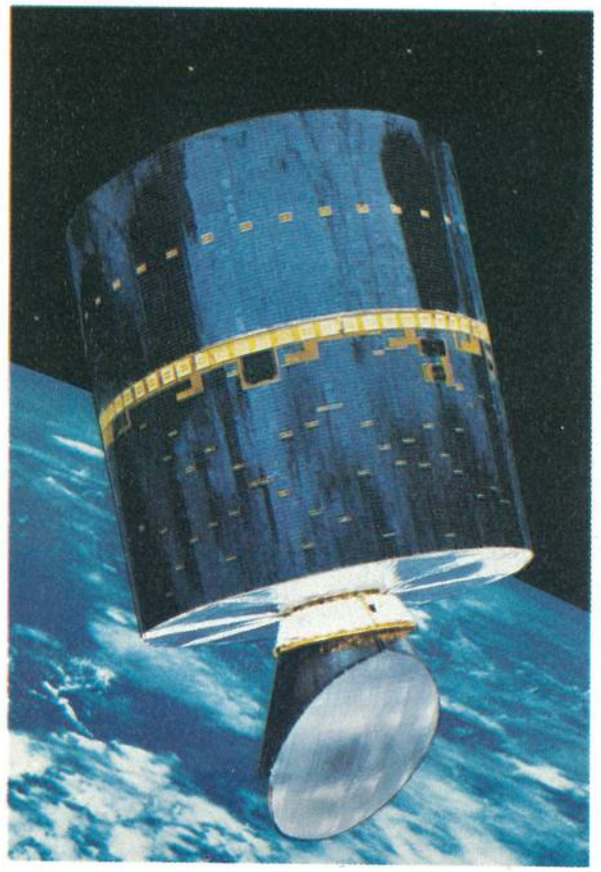
Experimental results obtained in the first experimental year are summarized as follows:

1) Characteristics of C-band and K-band transponders and performance of the onboard communication antenna have not exhibited any degradation.
2) Qualities of FM and PCM-PSK signals of TV and multiplexed telephone are good as expected, having transmission characteristics in C/No value better than 100 dB·Hz in K-band and 97 dB·Hz in C-band in satellite links between large scale ground terminals of 10 meter dish antenna class.
3) Valuable data of rainfall attenuation in quasi-millimetric waves in the satellite links have been accumulated.
4) Operation procedures of a large capacity PCM-PSK-TDMA system of 960 telephone channels and a small capacity ΔM-PSK-SCPC system have been established.
5) The satellite position and attitude have been kept within the accuracy better than ±0.1° by periodic maneuver operations.

and Main Fixed Earth Station for CS (right) at Kashima Branch of RRL

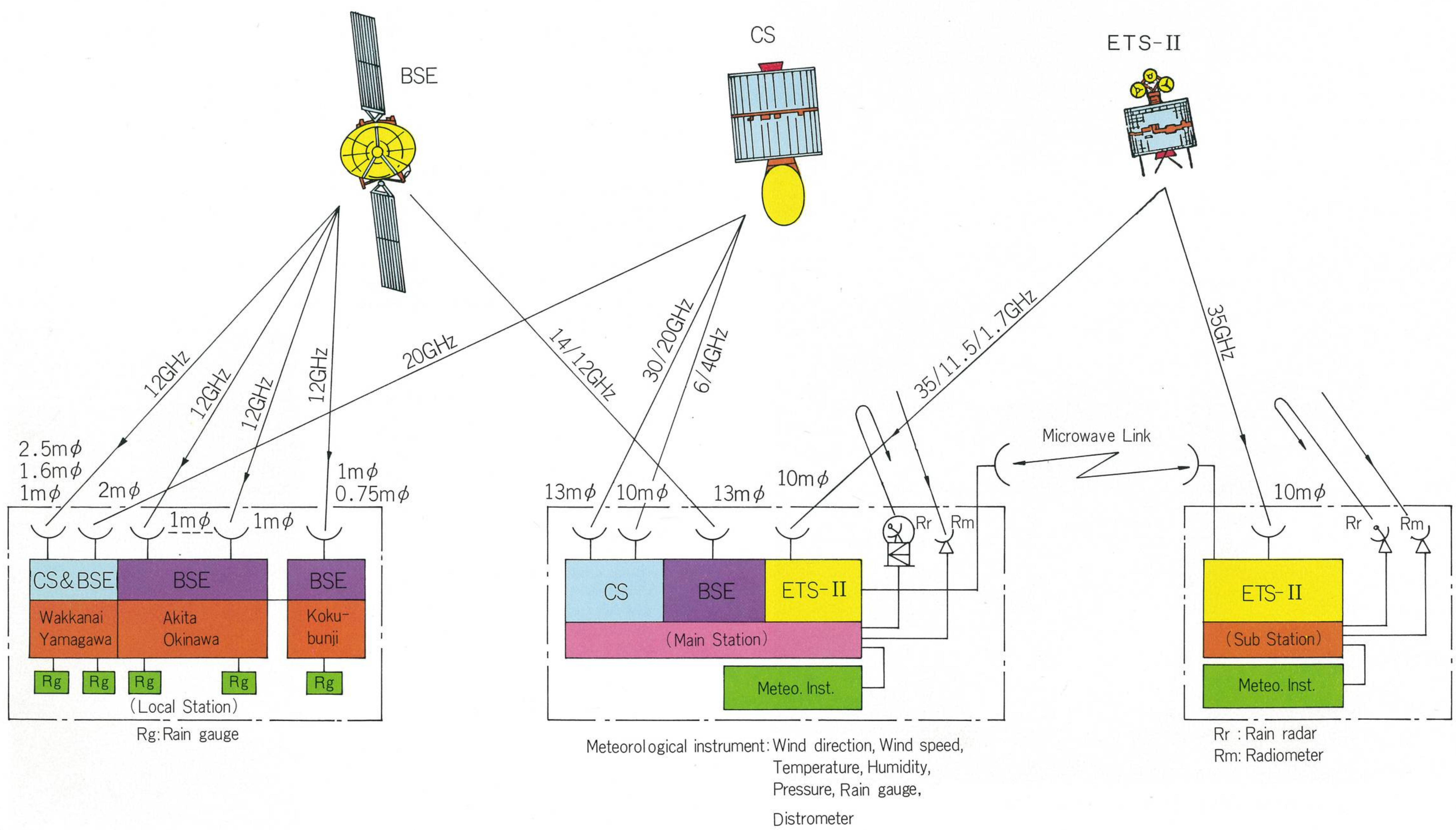
OUTLINE OF CS

Launch in Dec. 1977 by Delta 2914
135° E on geostationary orbit
3 year life
340kg at the beginning of life
Cylindrical type with shaped beam mechanically despun antenna
(D:2.2m, H:3.5m including antenna)
420W solar cell power source
S-band and C-band TT & C
Spin stabilization
Two C-band and six K-band channels



CS

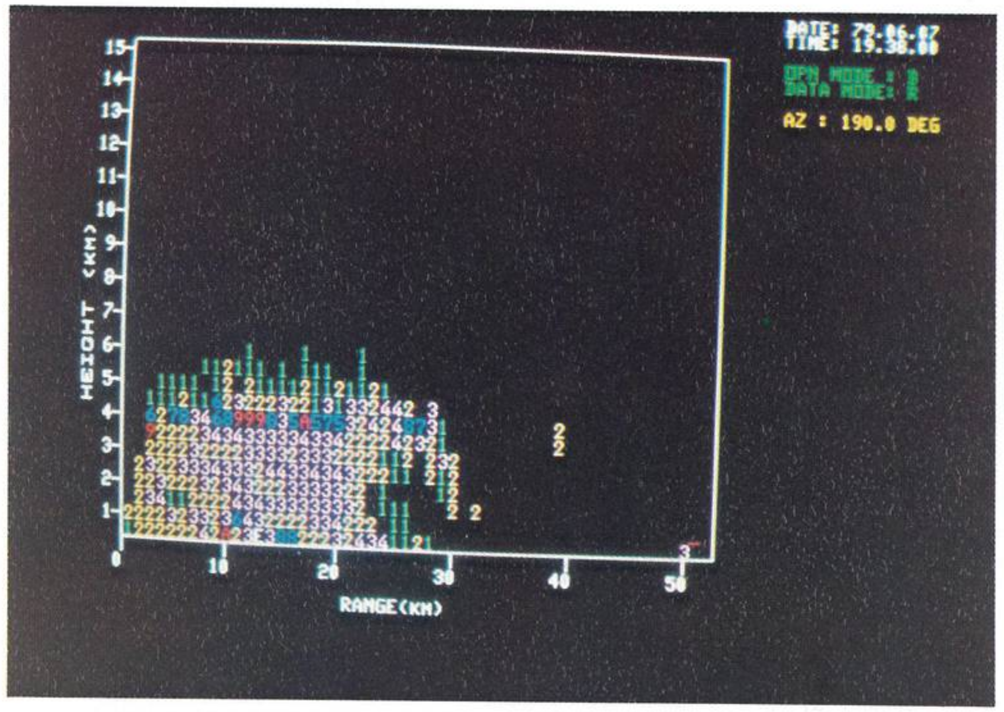
OUTLINE OF PROPAGATION EXPERIMENTS SYSTEM



In order to cope with huge amount of future communication capacities and complexity of communication methods, it is necessary to introduce domestic satellite communication and broadcasting systems in Japan.

RRL conducted satellite-to-earth propagation experiment for a year by using 1.7, 11.5, and 34.5 GHz beacon signals emitted from ETS-II which was launched in February 1977 and also obtained satellite-to-earth propagation characteristics. Based upon these results, RRL is continuing to make propagation characteristics clear by using 30/20 GHz bands of CS and 14/12 GHz bands of BSE which were launched in December 1977 and in April 1978, respectively.

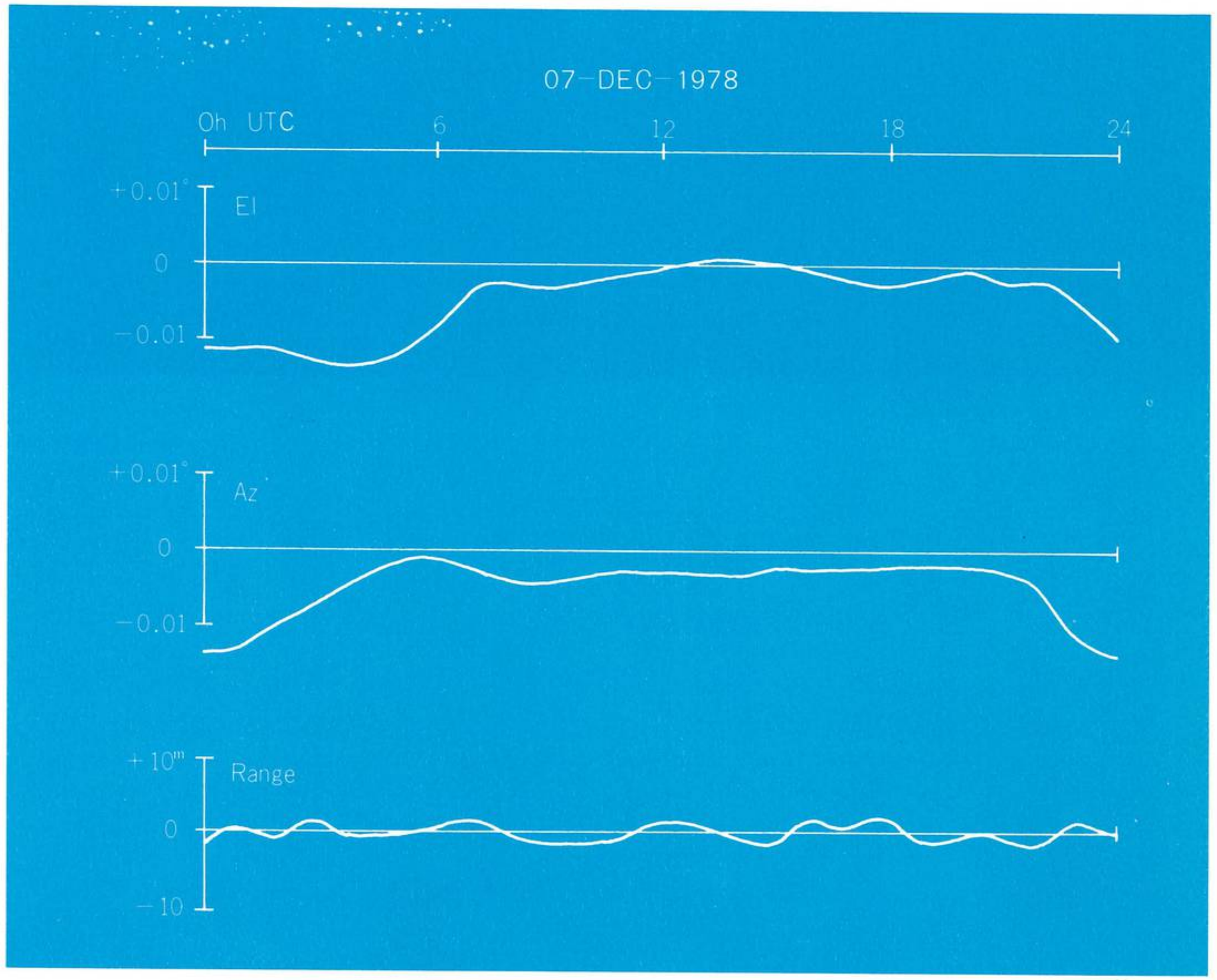
Alphanumeric characters in the picture below show the rainfall rate inferred from the radar reflectivity. Strong echo which is usually called "bright band" is observed at the altitude of 4km. The echo pattern of rainfall at this level is also shown on the cover. From the bright band and with the horizontal homegeneity of the rainfall, this rainfall is classified as stratus type.



Typical example of radar echo in RHI

SATELLITE CONTROL TECHNIQUE

As one of the CS and BSE experiments, the method of orbit determination of geosynchronous satellites has been studied for computation of simplification, high speed and high accuracy. The purpose has been achieved by developing the orbit determination program named KODS. This program uses a combined method of numerical and analytical integration, and it is also able to evaluate the system observability of satellite tracking networks. KODS will be applicable to orbit determination by VLBI data and optical tracking data.



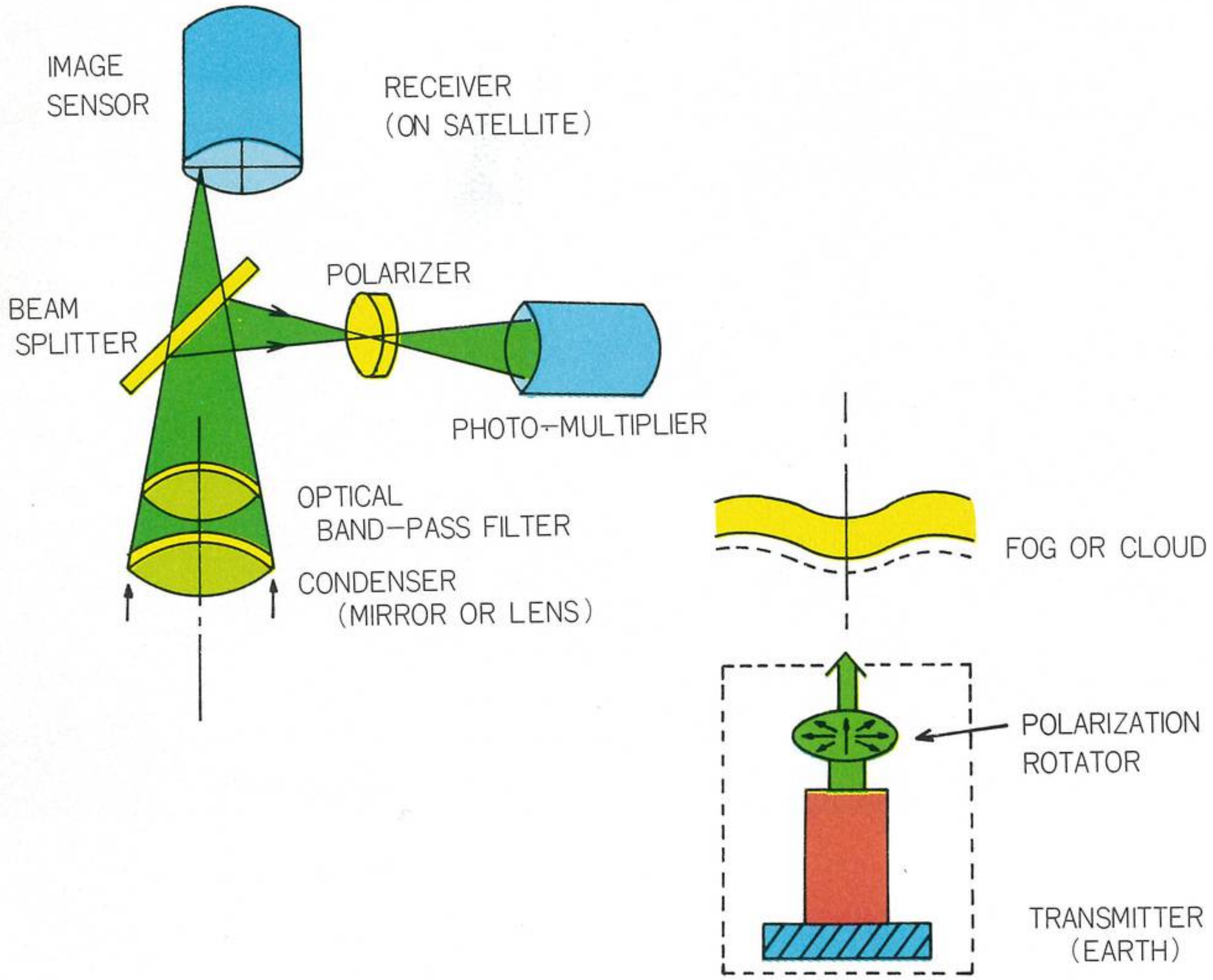
CS orbit determination residuals by KODS

ATTITUDE DETERMINATION OF SPACECRAFT BY USING LASERS

For increasing satellite communication channels and protection of terrestrial communications from those interferences, antennas on spacecraft need to have high gain and narrow beamwidth. Therefore, more accurate attitude determination and control are necessary in order to orient the antennas toward specific location on the earth or toward another spacecraft and communicate with high efficiency.

A new method to determine the attitude of spacecraft with high accuracy using a laser was proposed. This system consists of a transmitter of a linearly polarized laser beam on the earth and a receiving equipment on a relevant spacecraft. When the system is used for geosynchronous satellites, it is theoretically and experimentally confirmed that the accuracies of determination attain 10^{-4} rad. or higher for the angles which correspond to roll and pitch, and 10^{-2} rad. or higher for the angle which corresponds to yaw.

The atmospheric effects on laser beam propagation from the earth to the spacecraft will be investigated using the ETS-III satellite of Japan.



System for attitude determination of spacecraft using lasers

SATELLITE COMMUNICATION SYSTEMS FOR SMALL-SIZED SHIPS

The purposes of Aeronautical-Maritime Engineering Satellite (AMES) project are to carry out the communication experiments between ground stations and small-sized ship and airdorne stations, and the operational experiments on the aeronautical navigation systems and to establish the design and manufacturing technique of a spin stabilization geostationary satellite.

The AMES is jointly developed by the Ministry of Posts and Telecommunications (MPT), the Ministry of Transport (MOT) and National Space Development Agency of Japan (NASDA).

This satellite will be launched by an N-II launch vehicle from Tanegashima Space Center of NASDA.

Main Missions of AMES are as follows: 1) Establishment of the design rule and the manufacturing technique of a spin-stabilized geostationary satellite and evaluation of the performance of onboard components manufactured in Japan, 2) Operational experiments on the aeronautical navigation systems and maritime communication systems, 3) Measurement of the signal (voice, data and ranging data) transmission characteristics between fixed earth stations and ship stations, 4) Measurement and evaluation of the L-band radio wave propagation characteristics, 5) Evaluation of the performance of the onboard transponders and the L-band multibeam antenna, and 6) Development of the earth station equipments and onboard equipments of airborne and ship stations.

MULTIBEAM SATELLITE ANTENNA

Rapid advance in satellite technology now allows direct-to-home satellite TV broadcast, satellite-to-satellite communication, and satellite communication even for small mobile stations. To make these systems commonly operational, the systems should be inexpensive for the users. The realization of the inexpensive earth terminals needs for a communication or broadcasting satellite to radiate high equivalent isotropically radiated power (EIRP), for the communication satellite, in addition, to have the antenna with large gain over noise temperature ratio (G/T). Therefore large and high gain satellite antennas are commonly required for the systems. While the high gain antenna has the narrow beam, the beam should be multiplied to cover the desired area.

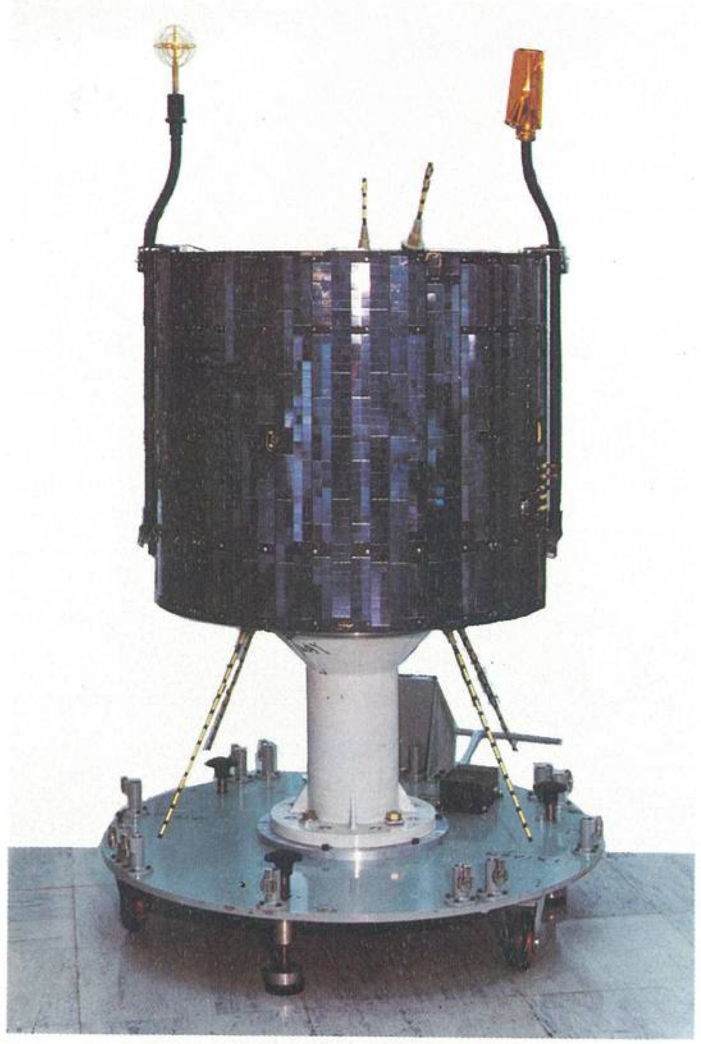
In the result, the multibeam satellite antenna (MBA) becomes necessary to make the above-mentioned systems commonly operational.

RRL is planning to develop MBA of excellent interbeam isolation and to develop the antenna analyzer using near-field measurement, which is necessary to R&D of MBA. The excellent beam isolation not only decreases the interference of the signals between different beams but also makes frequency re-use possible among the non-adjacent beams.

ISS-b IONOSPHERE SOUNDING SATELLITE

ISS project was proposed by RRL for the purpose of carrying out the world-wide observations of the ionospheric parameters and the radio noises in conjunction with the global survey of the radio environment having influence upon the radio communications.

The ISS-b was launched on February 16, 1978 from Tanegashima Space Center of NASDA by an N-launch vehicle.



ISS–b

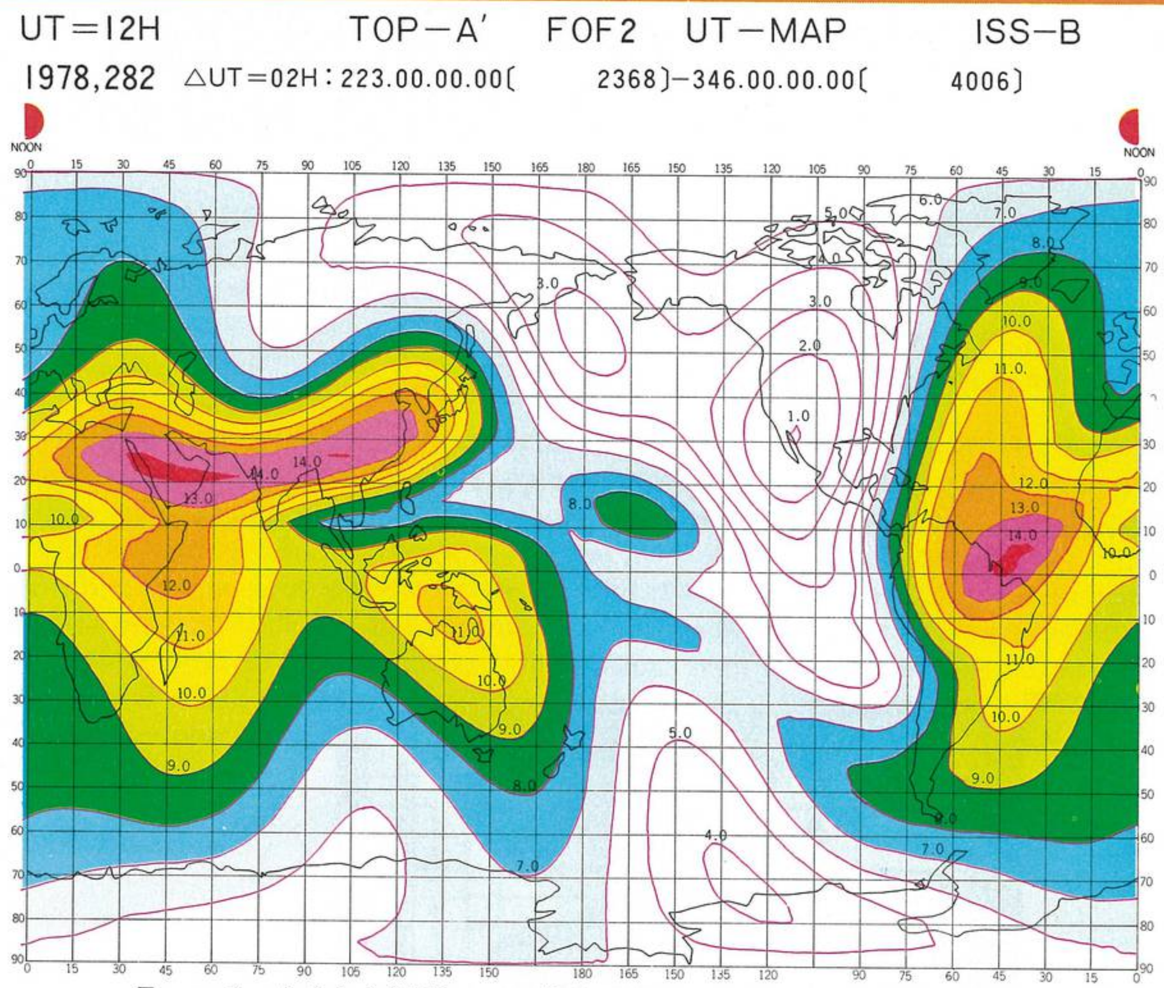
OUTLINE OF OBSERVATIONS

(1) TOPSIDE SOUNDING (TOP)
Frequency range : 0.5 to 15 MHz
Frequency step : 100 kHz
Pulse width : 300 μsec
Pulse peak power : 150W

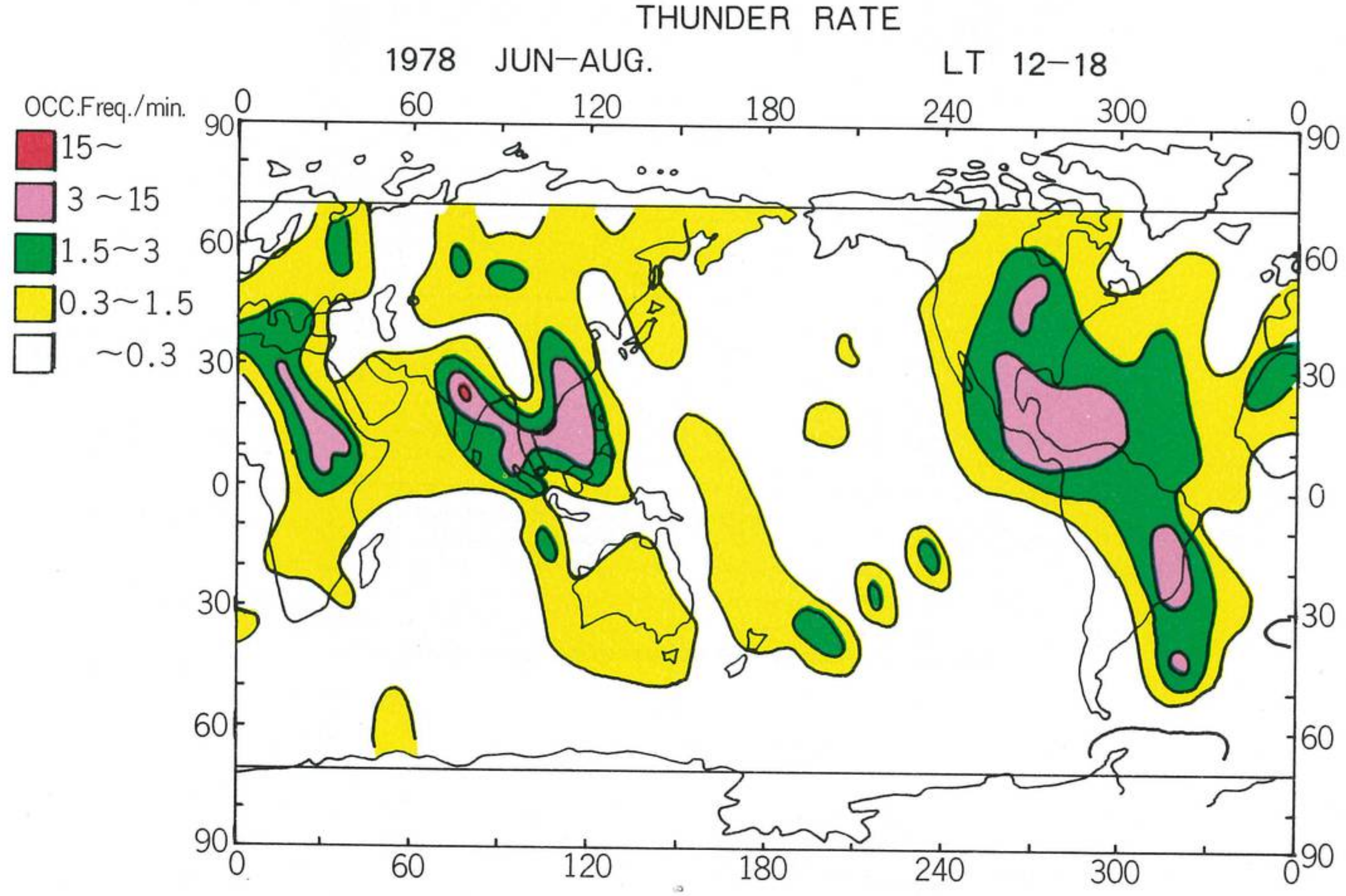
(2) RADIO NOISE MEASUREMENT (RAN)
Four channel narrow band HF radio noise receiver at 2.5, 5.0, 10.0 and 25.0 MHz

(3) PLASMA MEASUREMENT (RPT)
Electron and ion densities
: $10^3 - 10^6$ cm^{-3}
Electron and ion temperatures
: 500K – 5000K

(4) POSITIVE ION COMPOSITION MEASUREMENT (PIC)
Mass range : 1 to 20 AMU
Density of ion species
: $10^2 - 10^6$ cm^{-3}



Example of global foF2 maps ([redacted] 12h UTC, Aug.–Dec.)



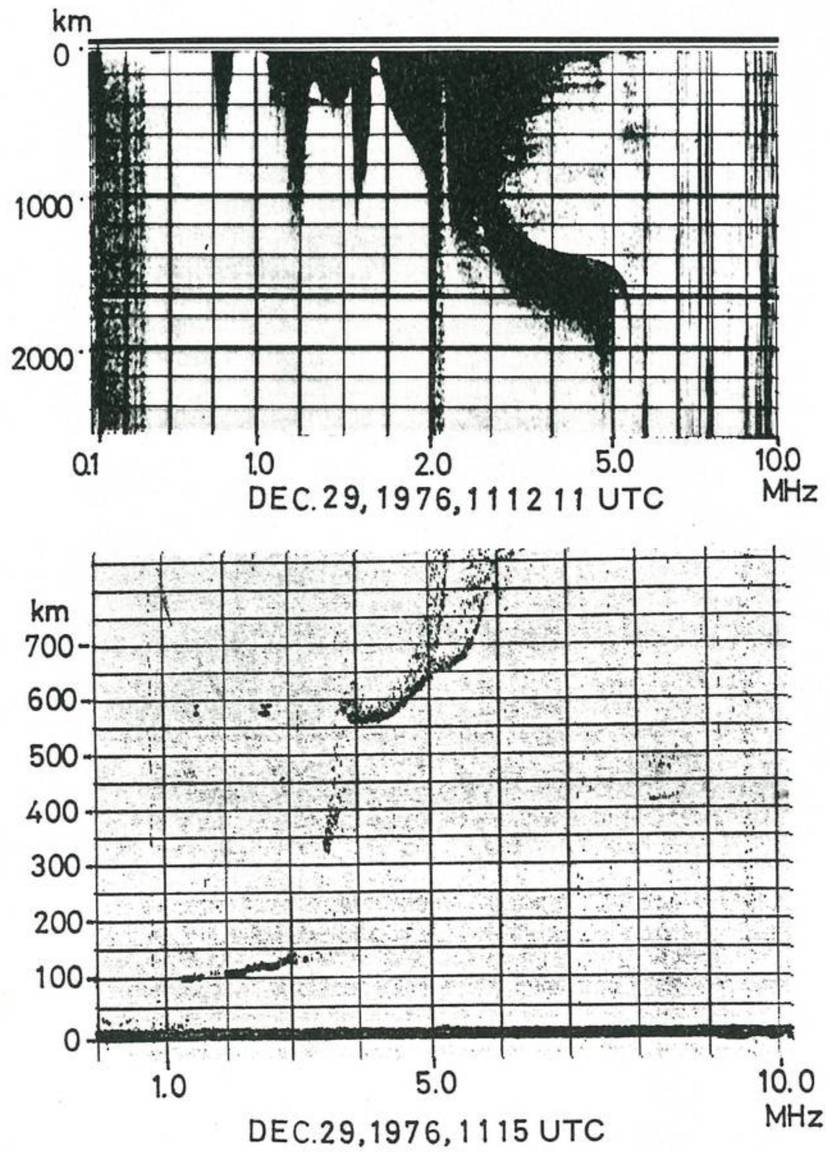
Example of global maps for occurrence rate of lightning discharge (summer [redacted] evening)

ISIS PARTICIPATION IN INTERNATIONAL SATELLITES FOR IONOSPERIC STUDIES PROGRAM

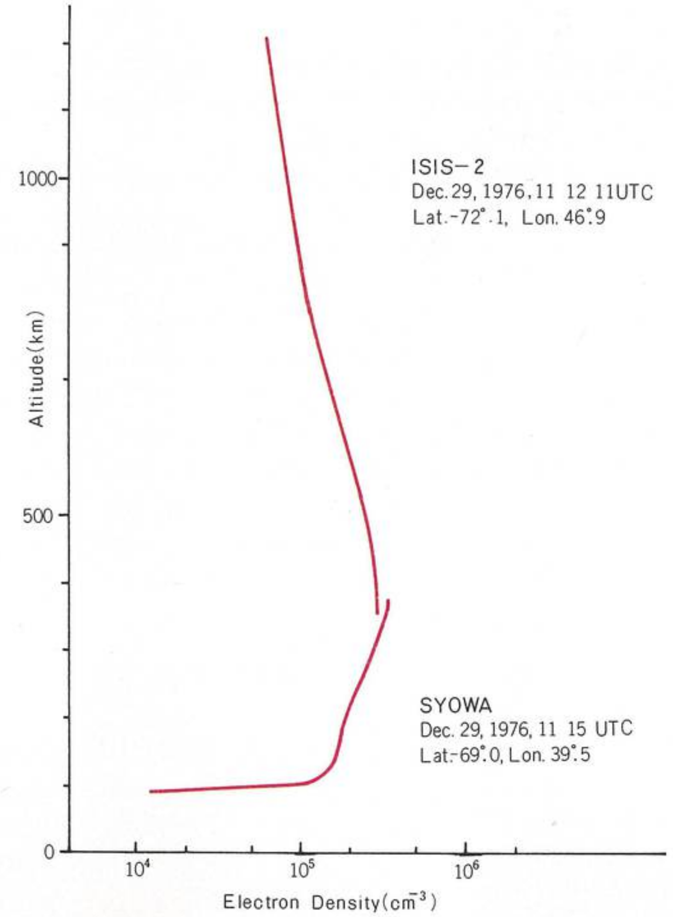
RRL joined the ISIS Working Group in August 1965. Since then the data acquisition at Kashima Station, RRL and the data processing and analysis at the RRL Headquarters have been performed for the satellites:

Alouette-1 (since August 1966 till November 1968),
Alouette-2 (since August 1966 till November 1971),
ISIS-1 (since July 1970 till present),
ISIS-2 (since May 1971 till present).

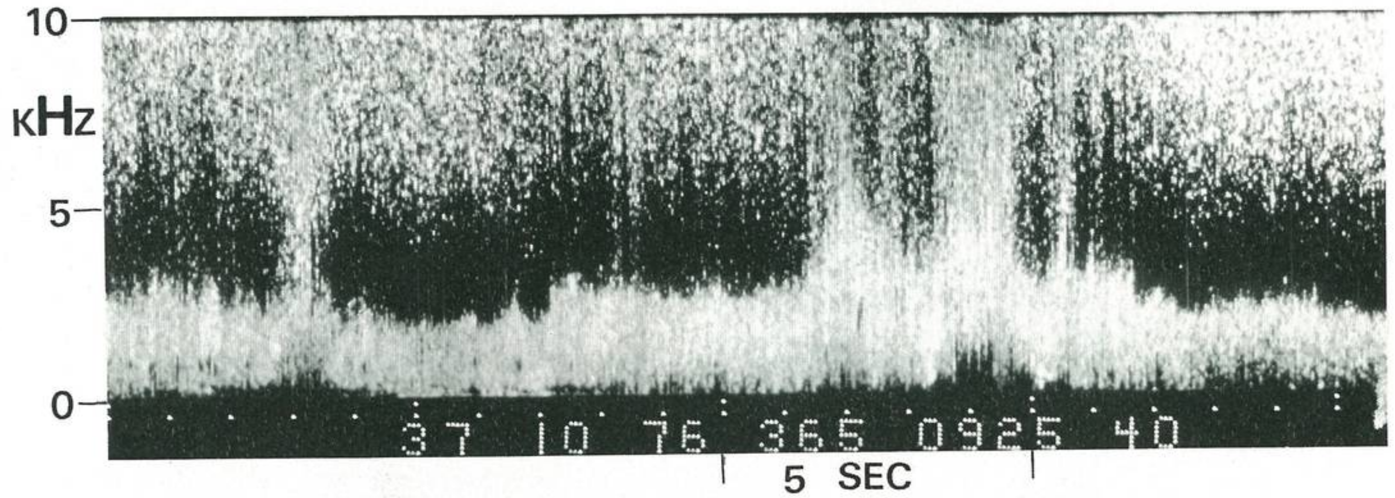
Since April 1976, the Japanese Antarctic Base, Syowa Station (69°00′S, 39°35′E) has joined the ISIS telemetry station network in cooperation with the National Insititute of Polar Research of Japan.



Topside ionogram from ISIS-2 observed above Syowa station (top) and bottomside ionogram observed at Syowa station simultaneously (bottom)



Electron density profile reduced from both topside and bottomside ionograms shown in the photograph



"Auroral Hiss" observed by ISIS-1 above Syowa Station, at 09h25m40s UTC on December 30, 1976 (geomag. lat. 77.2° S, height 2605km)

AERONOMY RESEARCH BY SPACE VEHICLE OBSERVATIONS

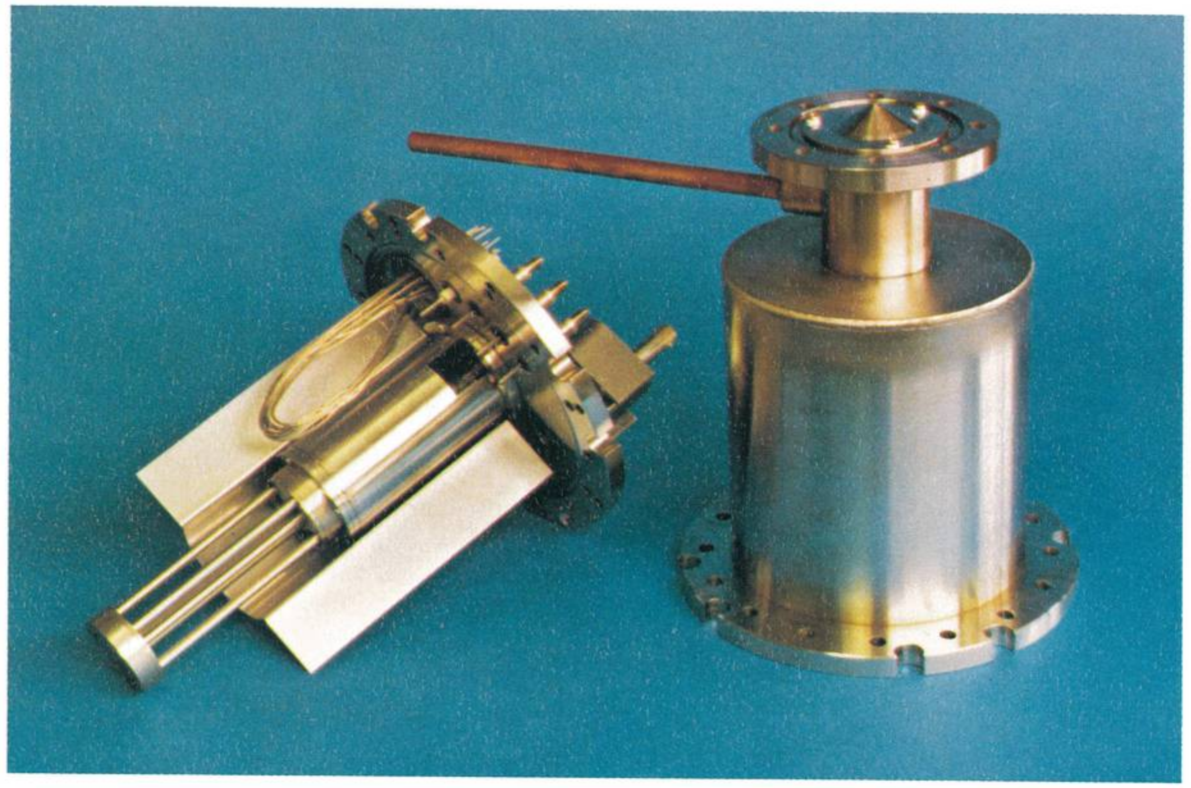
Various plasma probes, for example, radio-frequency resonance probes and electrostatic probes including retarding potential analyzer, have been developed for ionospheric observations during the past twenty years. The effectiveness of these probes has been proved by thirty-eight sounding rockets experiments made at the Akita Rocket Range and Kagoshima Space Center of University of Tokyo, and twenty-three rocket experiments at Syowa Station, Antarctica.

The composition in a neutral gas state and/or in a plasma state in the upper atmosphere has been studied by mass spectrometers aboard rockets and satellites. The stratospheric air composition at heights of 20-40 Km has also been measured by the mass spectrometer equipped in a balloon, in cooperation with University of Tokyo.

Additionally, laboratory experiments for studying the characteristics of the upper atmospheric plasma have been made by means of the space plasma chamber.

Recent emphasis is placed on researches of excitation and maintenance mechanisms of ionospheric plasma waves, and of global ionospheric modelings.

A future plan to follow ISS Project is being investigated in parallel with the development of new-type satellite-borne instruments.



Ion-mass spectrometer for rocket experiment

IMS INTERNATIONAL MAGNETOSPHERIC STUDY

The operational phase of the International Magnetospheric Study (IMS) which started in January 1976 with about 50 participating countries terminated at the end of 1979 to be followed by the analytical phase of the study.

The IMS program was planned as a concerted effort to acquire coordinated ground-based, balloon, rocket, and satellite data needed to improve our understanding of the behavior of the plasma environment of the earth.

RRL has taken part extensively in the program in various items as follows: 1) Ionosphere vertical sounding at the five Radio Wave Observatories (RWO) and the Antarctic Syowa Station, 2) VLF propagation study at the Inubo RWO, 3) Ionospheric wind observation with the meteor radar at the Akita RWO, 4) VLF emission and whistler study at the Wakkanai and Okinawa RWO's, 5) Ionospheric absorption measurements at the Hiraiso Branch and the Syowa Station, 6) Auroral radar observation at the Syowa Station, 7) Solar radio emission measurements at the Hiraiso Branch, 8) Rocket sounding of the ionosphere, and 9) Satellite (ISS-b) observations with four mission apparatuses. The Western Pacific Regional Warning Center and the World Data Center C2 for Ionosphere at the RRL Headquarters have been performing active services for the IMS program.

RADIO OBSERVATION OF METEORS

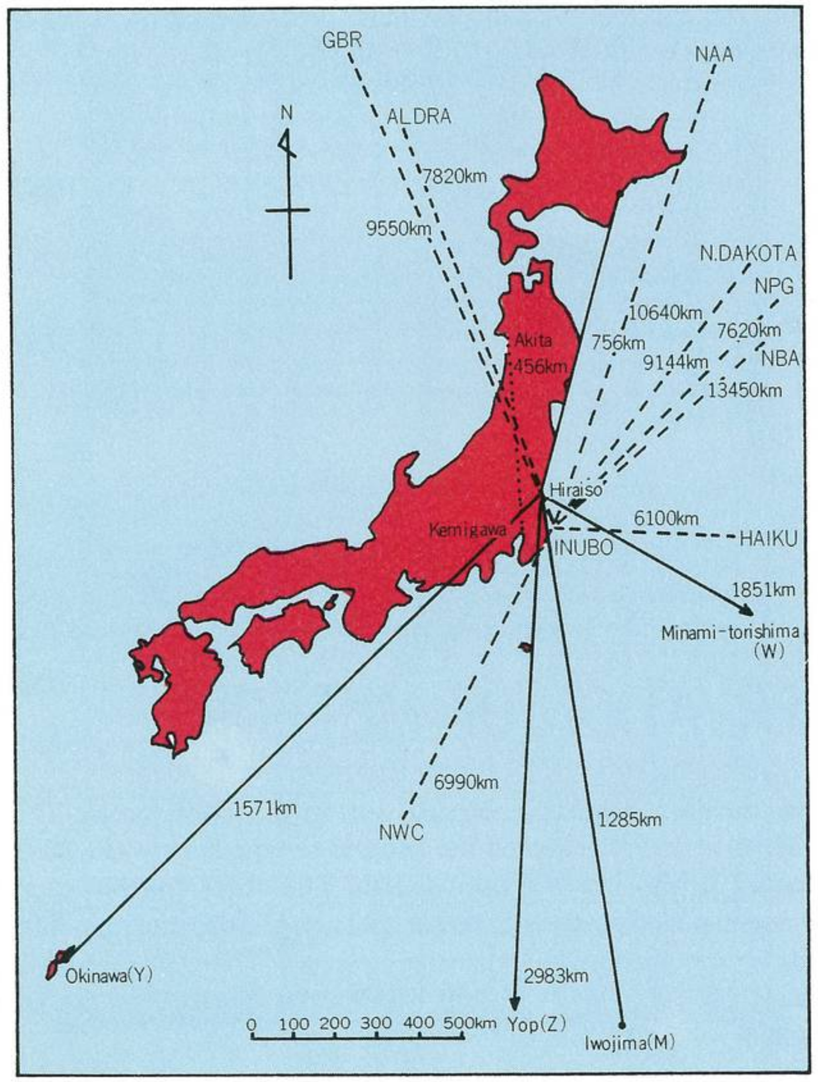
Observations of the meteors are being carried out with a VHF radar. The main purpose of this project is to deduce the wind and density of the neutral atmosphere in the meteor region (80-110 km) for studying the dynamics in the lower thermosphere. The other concern of this project is to obtain propagation data on meteor-backscattered waves necessary for studying the feasibility of meteor communication system.

Observations are made for eight days a month with special emphasis on the URSI-IAGA Cooperative Tidal Observation Program.

VLF AND LF RADIO PROPAGATION

At the Inubo Radio Wave Observatory, several VLF radio waves, including Omega waves, have been monitored with the aid of Cesium-beam frequency standard, while at the Hiraiso Branch, Loran-A(MF) and Loran-C(LF) waves have been received, in order to investigate propagational coditions during Sudden Ionospheric Disturbance (SID), Polar Cap Disturbance (PCD), Auroral Zone Disturbance (AZD) and other disturbances of the lower ionosphere.

These events have been published in "Ionospheric Data in Japan" and "Radio and Space Data", and also reported to "Solar Geophysical Data" published by NOAA, U.S.A.



Geographical disposition of LF radio wave circuits received at Hiraiso (Loran-C: 100kHz) and Akita (standard frequency: 40kHz) and VLF radio wave circuits at Inubo

HF WAVE PROPAGATION

The JJY standard frequencies have been received at the Wakkanai and Akita Radio Wave Observatories for researches on HF wave propagation over short distance through the ionosphere, especially the Es layer. Besides, it is planned to arrange the equipments capable of measuring doppler effect in order to study the movement of propagation media at two or three other observatories.

The data on long distance propagation of WWV (Colorado, U.S.A.) and WWVH (Hawaii) standard frequency waves at 15 MHz have been obtained since 1962 at the Hiraiso Branch operating as an international key station, published monthly in "Ionospheric Data in Japan", and also reported to the CCIR. The JJY waves have been received at the Syowa Station, Antarctica, for the study of HF waves propagation involving polar region in the path.

Recently, an FM-CW chirp sounder which covers frequency range from 2 to 30 MHz, was installed in the Hiraiso Branch, where transmission test has been carried out on the path covering Japan and the Federal Republic of Germany.

VHF WAVE PROPAGATION

Long range ionospheric propagation experiment in VHF band have been conducted in the full cooperation of Australia and Japan over the trans-equatorial path to clarify the ionospheric propagation mechanism of VHF waves. The reception rate of the signals, reduced from the long term experiment, shows higher values lasting for several hours from about 20 hour LT in both vernal and autumnal seasons.

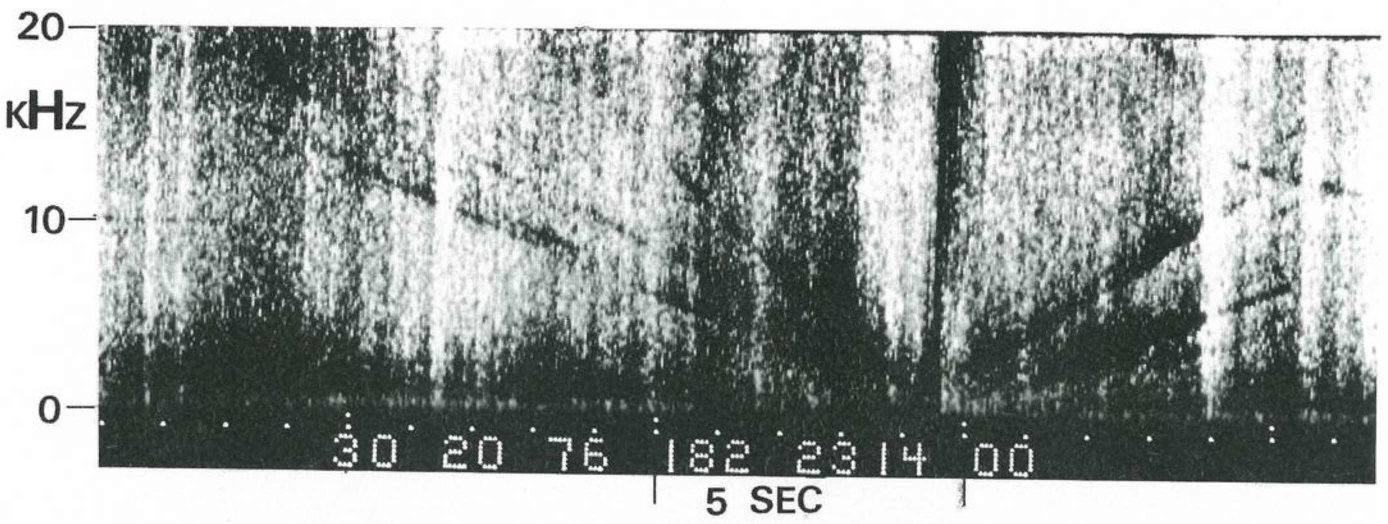
Well-developed Es layers make it possible that VHF waves propagate over the distance of about 2000 km, and cause interference on TV broadcasts or other communications. So, the Es layers are monitored and investigated in RRL.

VLF EMISSIONS AND WHISTLERS

VLF emissions and whistlers propagate along the geomagnetic field lines through the magnetosphere, and the characteristic frequencies of the magnetospheric plasma, such as the electron plasma frequency and the electron gyro-frequency are in the VLF band. So, VLF emissions and whistlers are the best means to observe the magnetosphere from low altitude satellites and on the ground.

RRL has conducted the telemetry reception of VLF data from the ISIS-1 and -2 at the Kashima Station, Japan and at the Syowa Station, Antarctica for investigating the propagation and generation characteristics of VLF emissions near the plasmapause and in high latitudes. The latitudinal structure of VLF emissions and whistlers gives us valuable information on properties of the magnetosphere. The picture shows an example of VLF emission, "the saucer", observed by ISIS-1 over the Syowa Station, Antarctica.

The observation of whistlers and their direction finding have been carried out at the Okinawa Radio Wave Observatory to study the whistler propagation in low latitudes, where the whistler trapping into the field-aligned duct becomes difficult. Many whistlers have been observed during winter nights at Okinawa, since the International Geomagnetic Reference Field line passing through Okinawa attains an altitude up to 765 km and enters an active area of thunderstorms in the east of Java Island.



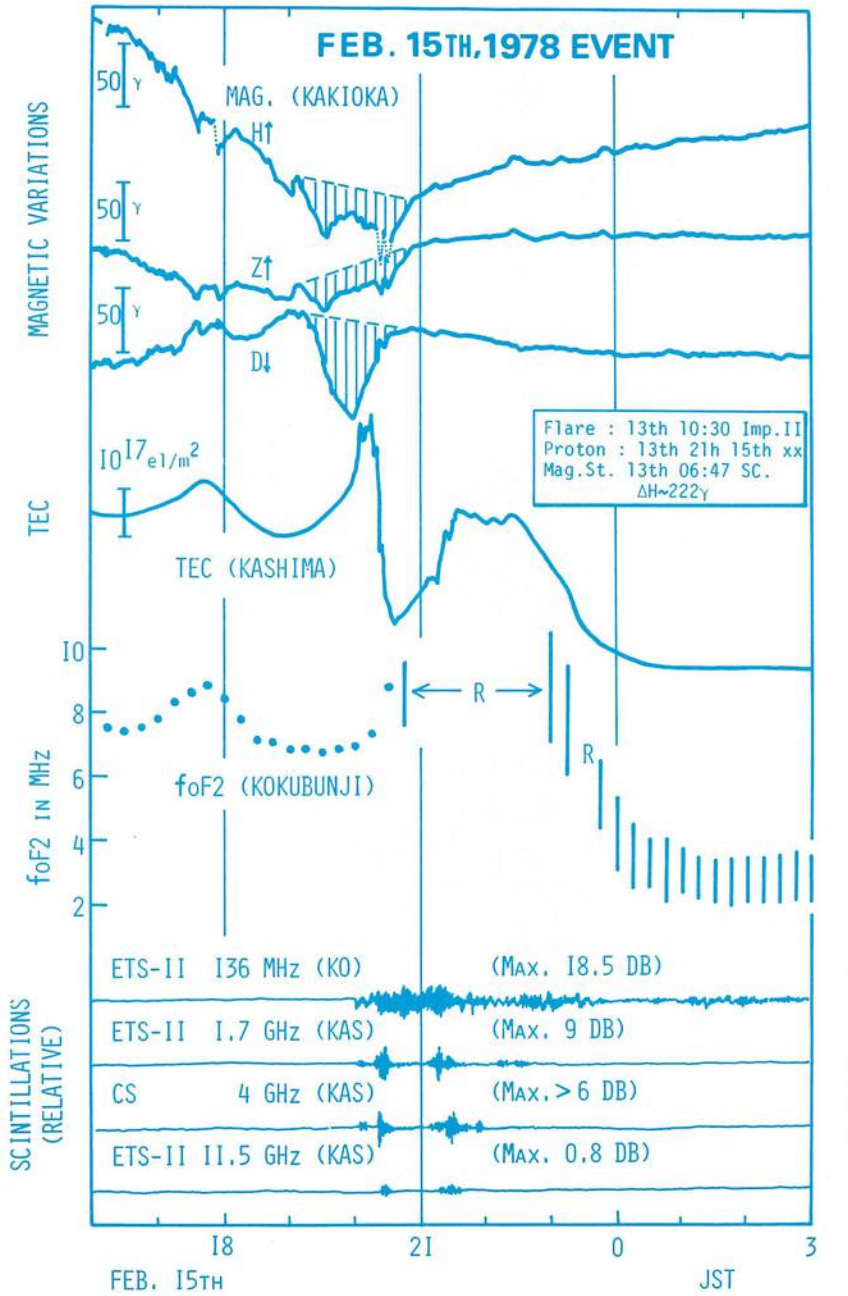
"Saucer Emission" observed by ISIS-1 around 23h13m UTC on June 30, 1976 (geomag. lat 81.2°S, hight 2010km, invariant lat. 79.1°, mag.LT 20h25m, Kp=4⁻)

IONOSPHERIC EFFECTS ON RADIO PROPAGATION ALONG THE EARTH-SPACE PATHS

Scintillations produced by the irregularities of electron density in the ionosphere yield serious problems to the satellite communications in VHF and UHF bands. And also, the time delay of radio signals produced by the total electron content (TEC) in the ionosphere causes serious errors to the satellite navigation systems.

Investigations of ionospheric effects by receiving radio signals from ETS-II, CS, BS, and the other geostationary satellites have been continued at the RRL Headquarters including the Kashima and Hiraiso Branches and the Radio Wave Observatories since 1977. This research includes not only the intensity measurements of various satellite radio waves but also the TEC measurements using ETS-II, by the Faraday rotation method in VHF range and the differential phase shift method between two co-herent waves in GHz range.

Investigations of the ionospheric effects upon satellite radio signals, including their time, space and frequency characteristics, are now in progress referring to the vertical ionospheric data obtained on routine base at RRL stations.



Example of severe scintillation records in association with a geomagnetic disturbance on Feb. 15, 1978

MICROWAVE REMOTE SENSING

Remote sensing of the earth environment by radio waves is one of the newly developed and most promising fields of the utilization of radio waves. Microwave remote sensors are advantageous for their effectiveness not only in day and night but also regardless of weather. An active microwave remote sensor to measure rainfall from satellite, "microwave rain scatterometer", is under development. The remote sensing of rainfall is important for satellite communication in microwave, because rain has great influence on the propagation of microwaves, especially higher than 10 GHz. Besides, the global observation of rain by satellite-borne remote sensor is very useful for monitoring of weather and climate variations. As a first step to the development of the satellite-borne microwave rain scatterometer, the X-band and Ka-band microwave rain scatterometers together with the same band microwave radiometers have been developed and the experiment to measure rainfall from airplane by the sensors is conducted. Relating to this experiment, the measurement of rainfall attenuation of millimeter waves by the FM-CW radar has been performed by the use of the large scale rainfall simulator of National Research Centre for Disaster Prevention, the Science and Technology Agency. Method of analysis and effective utilization of the data taken by microwave remote sensor are studied, and the development of various remote sensing techniques using radio waves including synthetic aperture radar system is also planned.

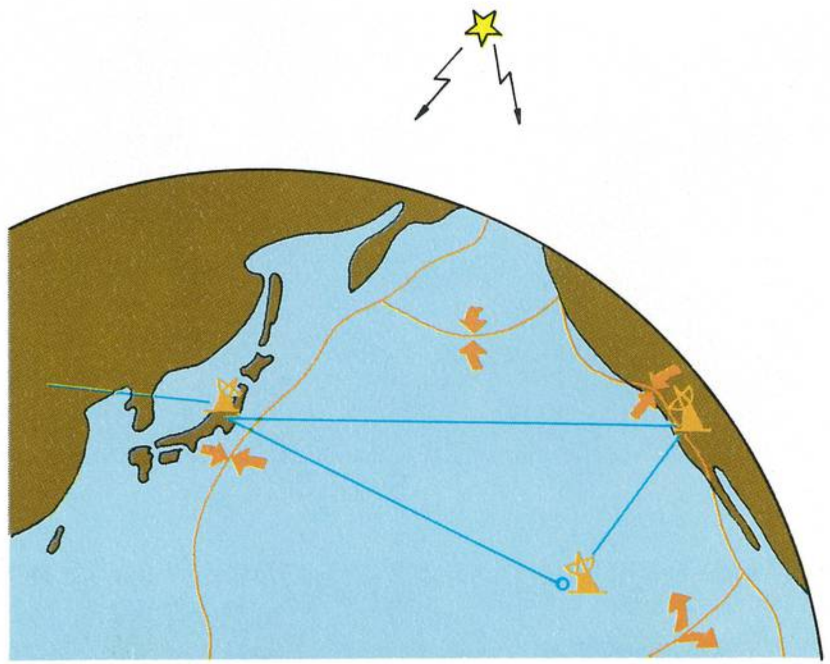
Experiment of millimeter wave attenuation due to rainfall by an FM- CW radar

VLBI AND RADIO ASTRONOMY

In very long baseline interferometry (VLBI), the radio signal produced by a distant source is received simultaneously at two radio antennas. By cross-correlating the two signals, the time delay can be determined very precisely (our goal of time delay resolution is 0.1 ns). VLBI has various kinds of application fields, such as resolution of celestial radio sources, orbit determination of geostationary satellite, geodesy, astrometry, polar motion, earth rotation and so on.

Our first domestic VLBI experiment was carried out between Kashima and Yokosuka (baseline length: 121 km) in Jan./Feb. 1977. The delay resolution of that experiment was 5 ns. RRL five-year plan, "Development of High-Precision VLBI System", and phase scintillation measurement with the use of VLBI technique, are now going on. In the last year of the five-year plan, 1983, Japan-U.S. system-level experiment will be performed, using a large paraboloidal antenna of 26m.

On the other hand, many kinds of radio astronomical observations have been made at Kashima, and one of them is observation of linearly polarized radio wave from Crab nebula during its passage through the solar corona in the midst of June. Besides, measurements of various characteristics of large antennas at Kashima in millimeter and quasi-millimeter waves have been made by observing celestial radio sources, such as Venus, Cas-A, Tau-A, etc.



VLBI system configuration

PARTICIPATION IN THE ANTARCTIC RESEARCH PROGRAM

Since the IGY (1957-1958), observations of the ionosphere have been carried out at the Syowa Station, located at 69.0°S, 39.6°E in the Antarctica, under the project of the Japanese Antarctic Research. Items of the ionospheric observations for which RRL is responsible are vertical sounding of ionospheric layers, measurements of ionospheric absorption with riometers, observations of radio aurora in VHF band, and receptions of HF and VHF radio signals. Sometimes, intensified observations by rockets with ionospheric sensors, such as electron density probes, high energetic particle detectors and radio receivers are made in order to clarify the mechanism of various polar phenomena including aurora, ionospheric sporadic E layers, geomagnetic disturbances, VLF emissions, etc.

Aurora above the Syowa Station

THEORETICAL STUDY OF RADIO WAVE PROPAGATION

I. STATISTICAL THEORY OF WAVE PROPAGATION IN RANDOM MEDIA

In the last decade, a considerable progress has been made in theoretical study of wave propagation in turbulent air and random particles. The moment equations of wave function have been derived for various orders and solved, in different approximations, for the typical atmospheric models of Gaussian and Kolmogorov turbulence spectra. This includes the theories of the so-called spot-dancing of narrow optical beam and also of the irradiance distribution, known experimentally to be close to the log-normal distribution. The conventional transport equation can be derived, to a very good approximation, from the equation of mutual coherence function of wave. The space-time transport equation has been used to evaluate the average intensity and time-spreading of light pulse waves both in turbulent air and random particles, like rains, fogs, clouds, etc. Further from the space-time transport equation, it has been derived the diffusion equation, which is valid in a domain of sufficiently large optical distance from wave source in space and time, and has been used for the study of light pulse propagation.

II. THEORY OF GROUND WAVE PROPAGATION OVER IRREGULAR TERRAIN

More than twenty years ago, a systematic theory was accomplished for the ground wave propagation over an irregular terrain consisting, along the path of wave propagation, of hills, cliffs, bluffs, etc. of special forms, and the expression of wave intensity was given in terms of a multiple residual series, corresponding to the Bremmer residual series for radio wave propagation over a homogeneous spherical earth. The theory covers the cases of so-called mixed path where the electrical property of a smooth spherical earth changes discontinuously several times along the wave path, like a land-sea-land path.

III. THEORETICAL STUDY ON SCATTERING AND ABSORPTION OF RADIO WAVES DUE TO RAIN

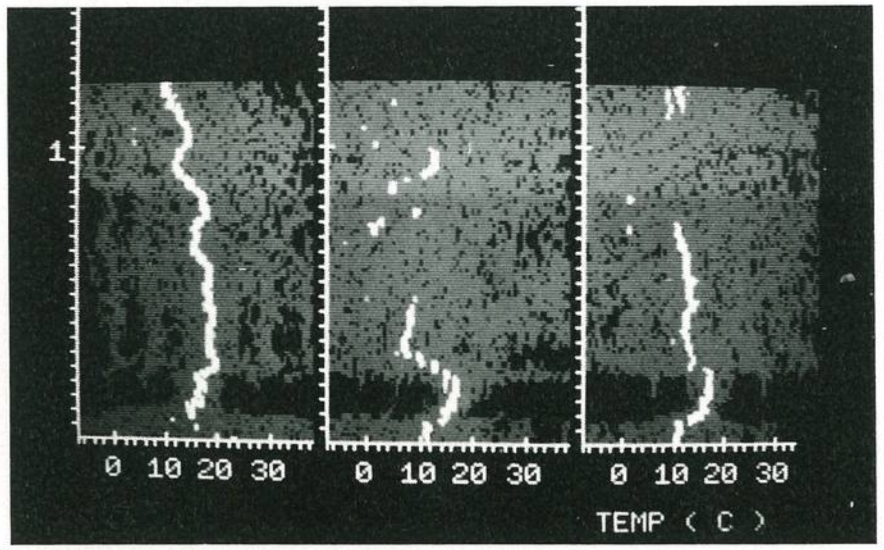
The scattering and absorption of radio waves by hydrometeors (especially in the form of rain) yield serious problems in terrestrial and satellite communications at the millimeter wave band. In this connection, theoretical calculations have been conducted. The main results hitherto obtained include calculations of the scattering properties of distorted raindrops at 4 – 50 GHz band, differential attenuation and differential phase shift due to rain between two orthogonally polarized waves. Calculation of the multiple scattering effect on attenuation and cross polarization is now in progress, by means of numerically solving the transport equation.

OBSERVATION OF TROPOSPHERE

The structure of the lower troposphere has been studied since 1970 in a series of observations by utilizing the method of acoustic wave backscattering for the purpose of increasing the knowledge of radio wave propagation and air pollution meteorology. These observations using the well-designed acoustic sounder system have yielded useful results including the characteristics of inversion layers, turbulent layers, thermal plumes, and internal gravity waves found in the atmospheric boundary layer.

As a new technique to observe the lower troposhere, a radio acoustic sounding system (RASS) which is composed of a 445 MHz CW doppler radar with two 3mϕ parabolic antennas and a tone burst transmitter with a 1.5mϕ parabolic antenna was developed in 1978 and the improvement of this system is now in progress. By using RASS, sample data of real-time atmospheric temperature profiles up to the height of several hundreds and occasionally to 1200 meters have been obtained.

The RRL RASS



Example of the atmospheric temperature profile observed by using the RRL RASS

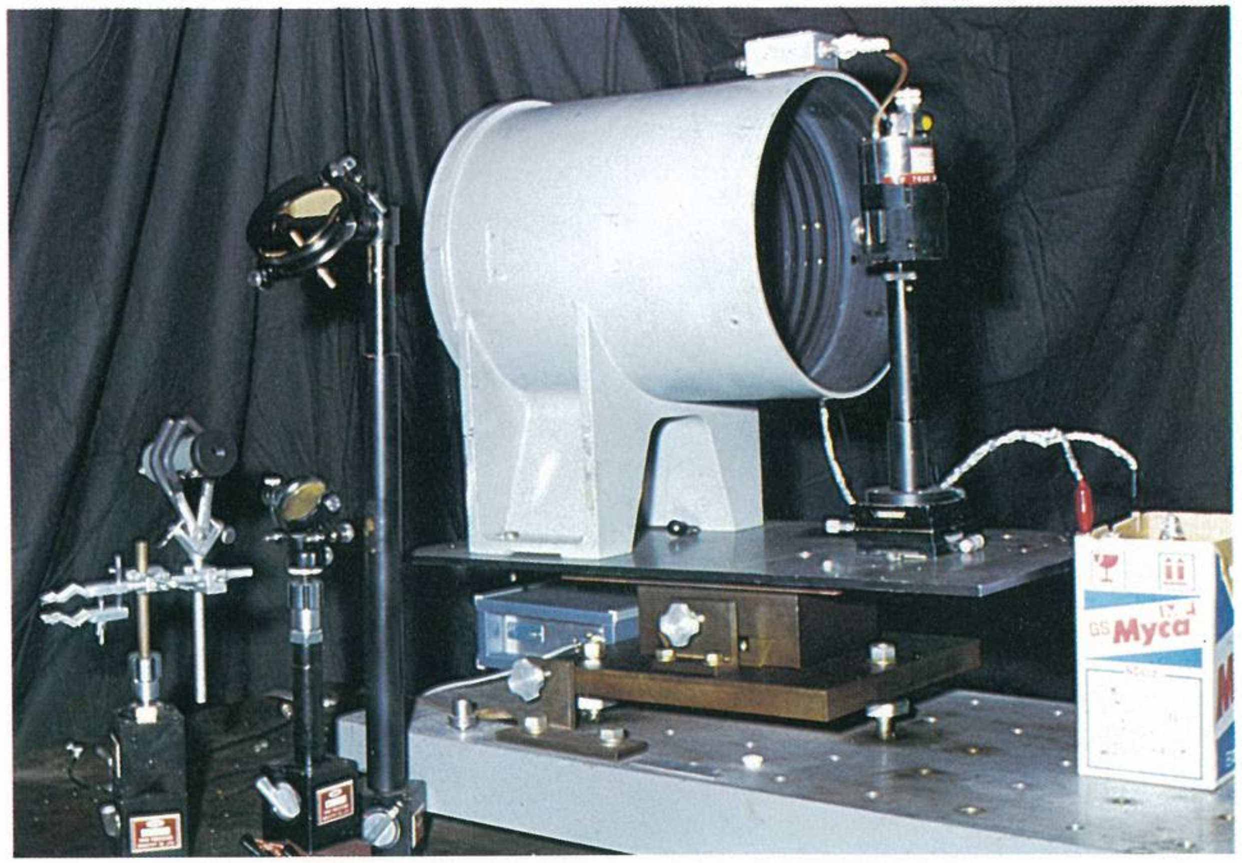
DETECTION OF AIR POLLUTANTS WITH LASER RADARS

For detecting and monitoring air pollutants, the optical methods are superior to the wet chemical ones now in use, for the former can be used for real-time remote sensing and measuring. Especially the differential absorption laser radar offers the best sensitivity.

Since 1969, studies of the differential absorption laser radar have progressed at RRL.

Recently a 9.6 μm CO_2 laser radar has been developed for measuring spatial ozone distributions for a photochemical smog. Concentrations of ozone were measured from 0.5 km to 2 km with the accuracy ranging from ±15 ppb to ±40 ppb. Experimental results showed good agreement between the ozone concentrations measured with the laser radar and those measured by point monitoring at various sites.

For monitoring regional ozone concentrations, RRL is conducting research of an air-borne laser radar system consisting of a CW 9.6 μm wave guide CO_2 laser and an infrared heterodyne receiver.



9.6μm laser radar optical system (receiver and transmitter)

COMPUTER NETWORK SYSTEM VIA SATELLITE

Research on computer network systems is in progress, in which a large number of small (i.e. low traffic) users communicate with each other or a central computer, through a packet-switched satellite channel, using a random access scheme.

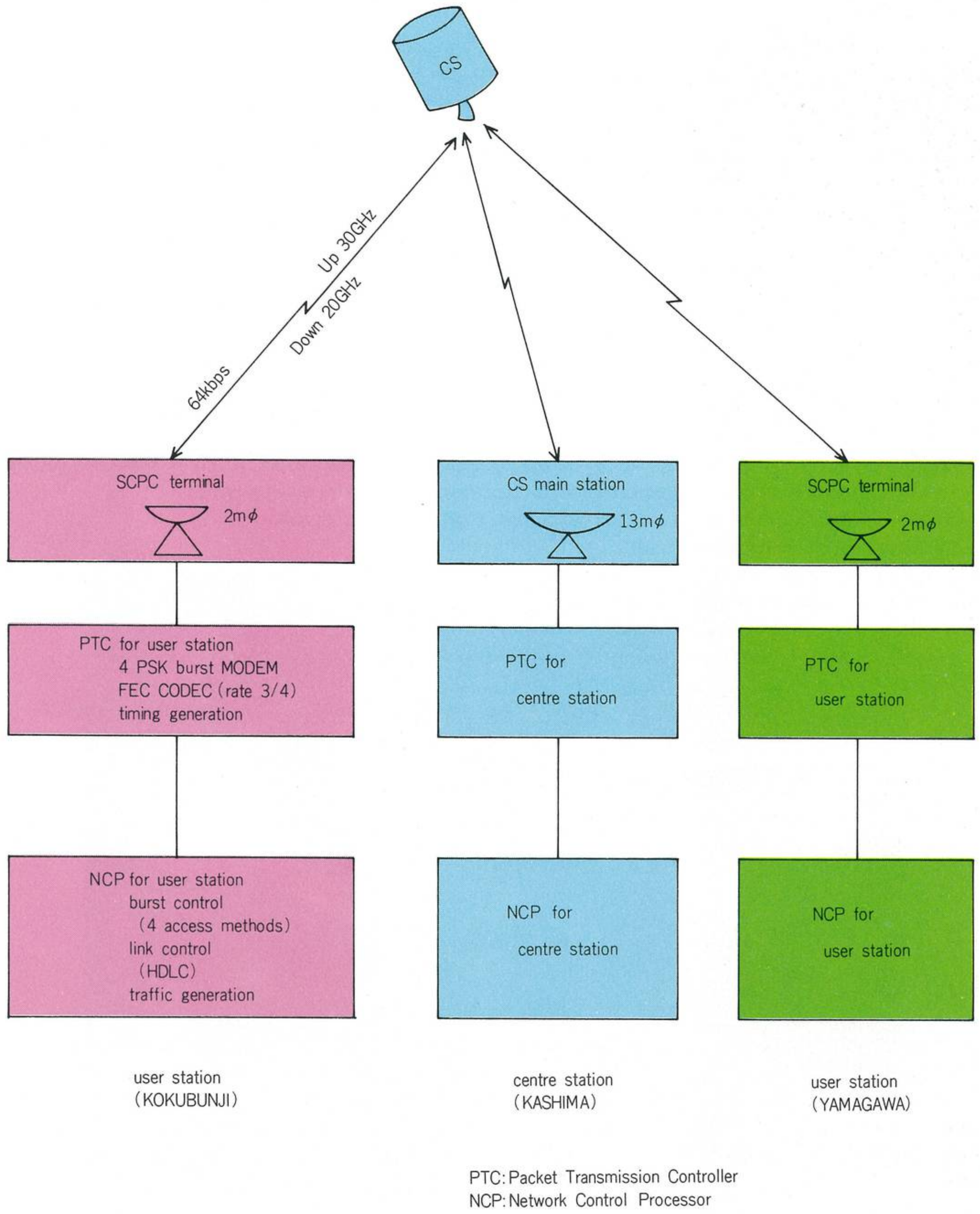
In order to establish a computer network system via satellite, a computer network experiment using CS is carried out to get basic data.

One of the main goals of the experiment is to evaluate the method of multiple access, namely, slotted ALOHA, slot reservation access (1 channel), slot reservation access (2 channel) and composite access.

To make the system more realistic, fifteen fake stations are emulated in each user station.

The main experiments items are as follows:

1) Experiments on basic transmission characteristics of burst mode signals, and
2) Measurement and evaluation of the performance of PROTOCOL (link and burst control).



Configuration of the experimental computer network system

MEASUREMENT OF MAN-MADE RADIO NOISE

For the measurement and control of man-made radio noise, the measuring instrument employing a quasi-peak or peak detector has been usually used. Such a measuring method is not sufficient for evaluating the effects of the radio noise on the performance of various communication systems.

Recently an instrument was developed in RRL for measuring statistical characteristics of man-made radio noise, such as Amplitude Probability Distribution, Noise Amplitude Distribution and others. Using the instrument, investigations are being made on the characteristics of radio noise generated by automobiles, electric appliances and many other electrical apparatuses.

MEASUREMENT TECHNIQUES OF RADIO EQUIPMENTS

Due to the inscrease of radio stations and the complication of electronics, speedier and more precise measuring methods than ever are required for the legal test of the radio equipments.

Recently, three kinds of measuring methods have been developed as follows:

1) Occupied bandwidth measurement

The new apparatus utilizes a spectrum analyzer, and the features are based on the wide flexibility of this analizer regarding to frequency, bandwidth and type of emission.

2) High speed measurement of spurious response immunity

A new method was developed successfully for FM receivers.

3) Immunity measurement of receiver

A test method of receiver immunity to interference waves was developed for auto-alarm receivers.

DETECTION AND LOCATION TECHNIQUES OF RADIATION SOURCE

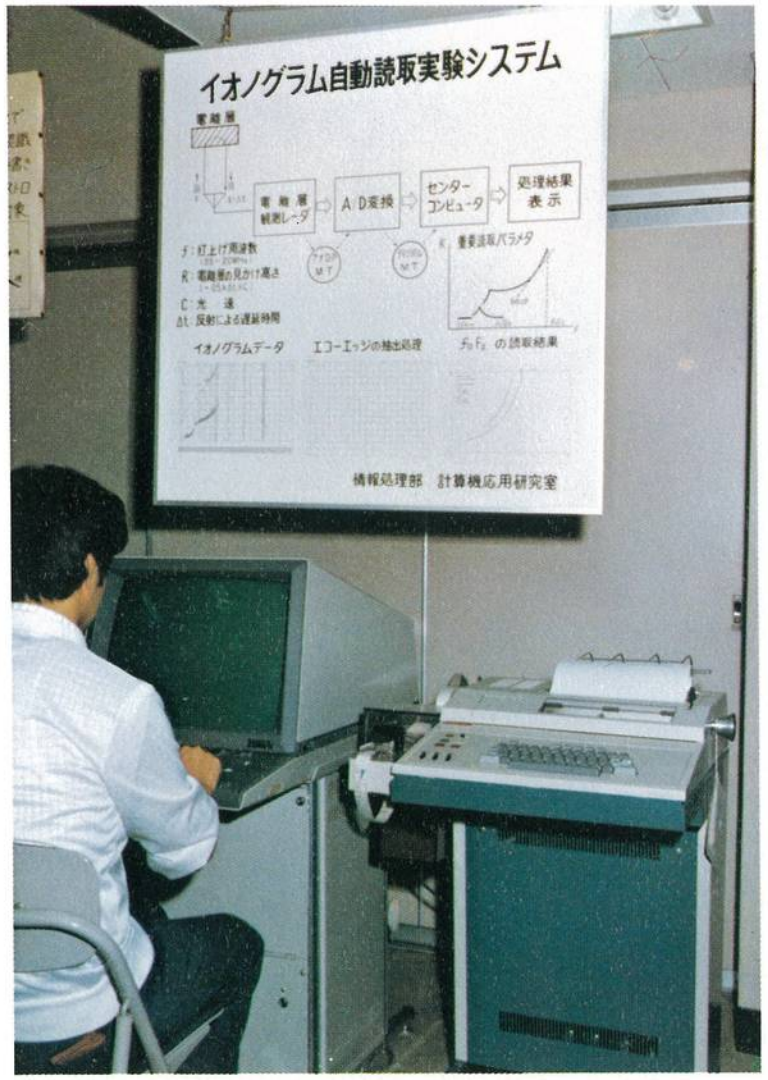
Recently there are many radiation sources of communication and broadcasting systems in VHF and UHF bands. Therefore, any spurious and illegal emissions may cause interference on the communication systems, so the techniques to find out illegal radiation sources are eagerly required. It is very difficult, however, to locate an illegal source, especially in a metropolitan area where many skyscrapers scatter the radiated wave over multiple paths. The studies of detection and location of an illegal source have been carried out.

VISUAL INFORMATION PROCESSING

Television and facsimile systems are generally used for the transmission of visual information by electrical communication techniques. Some experimental researches of bandwidth compression of visual information signals are carried out for efficient use of radio and wired communication systems.

In recent years, increasing research attention has been paid to automatic recognition of hand-written Chinese characters. However, the problem is still regarded extremely difficult because of the multiplicity, complicated structure and individual variation of the character patterns. A system for character recognition by Analysis-by-Synthesis method is under investigation. The system is based on the fact that a Chinese character can be drawn as a sequence of a few types of fundamental strokes and that each stroke in a character can also be described in terms of a fairly simple model of penpoint movement.

Analysis of radar images by computer is another important subject. An automatic processing system of ionosphere observation radar images (ionograms) is under development.



Display terminal for computer processing of ionosphere observation radar image

SPEECH PROCESSING

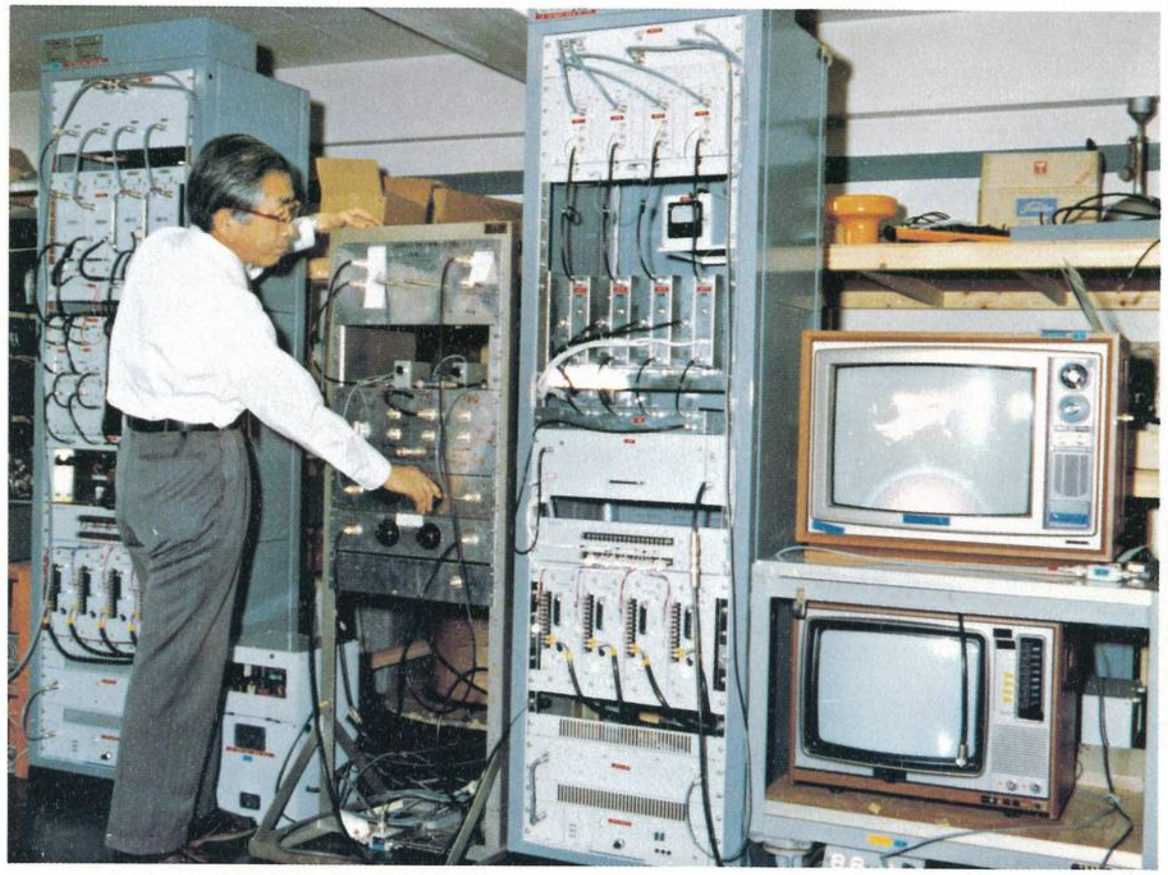
In a radio communication circuit, the quality of transmitted speech signal sometimes deteriorates because of fading, noise, and interference from adjacent channels. On the other hand, effective utilization of radio wave is an urgent problem in mobile and satellite communications. In order to solve such problems, efforts are concentrated on improvement in the signal to noise ratio of received speech signal and development of a low-bit-rate transmission system of speech.

A new speech processing system named SPAC (Speech Processing system by use of Auto-Correlation function) was developed in 1975. SPAC can compress or expand the speech spectrum, shorten or lengthen the duration of utterance, and reduce the noise included in speech signal. SPAC can be used in various fields of speech communications and its effectiveness is revealed analytically and experimentally. Furthermore, it is shown that ADM (Adaptive Delta Modulation) whose bit rate is 8 kbps is acceptable if SPAC is employed for reduction of the distortion caused by the low-bit-rate.

An experimental model of SPAC

TECHNIQUES FOR COST-REDUCTION OF SMALL POWER TV TRANSLATOR

This project was carried out in cooperation with the Study Group for Cost-reduction of Small Power TV Translator. In Japan, many people have recently needed television services in their daily life. But there are many areas where only a few TV channels can be received, due to blocking of TV waves by mountains, hills, etc., and due to TV translating equipment cost. Studies have been made on the techniques and specification for cost-reduction of small power TV translators, especially in the case of many TV channels.



53FG small power TV translator (10W & 3W trial set)

FREQUENCY STANDARDS

ATOMIC FREQUENCY STANDARDS

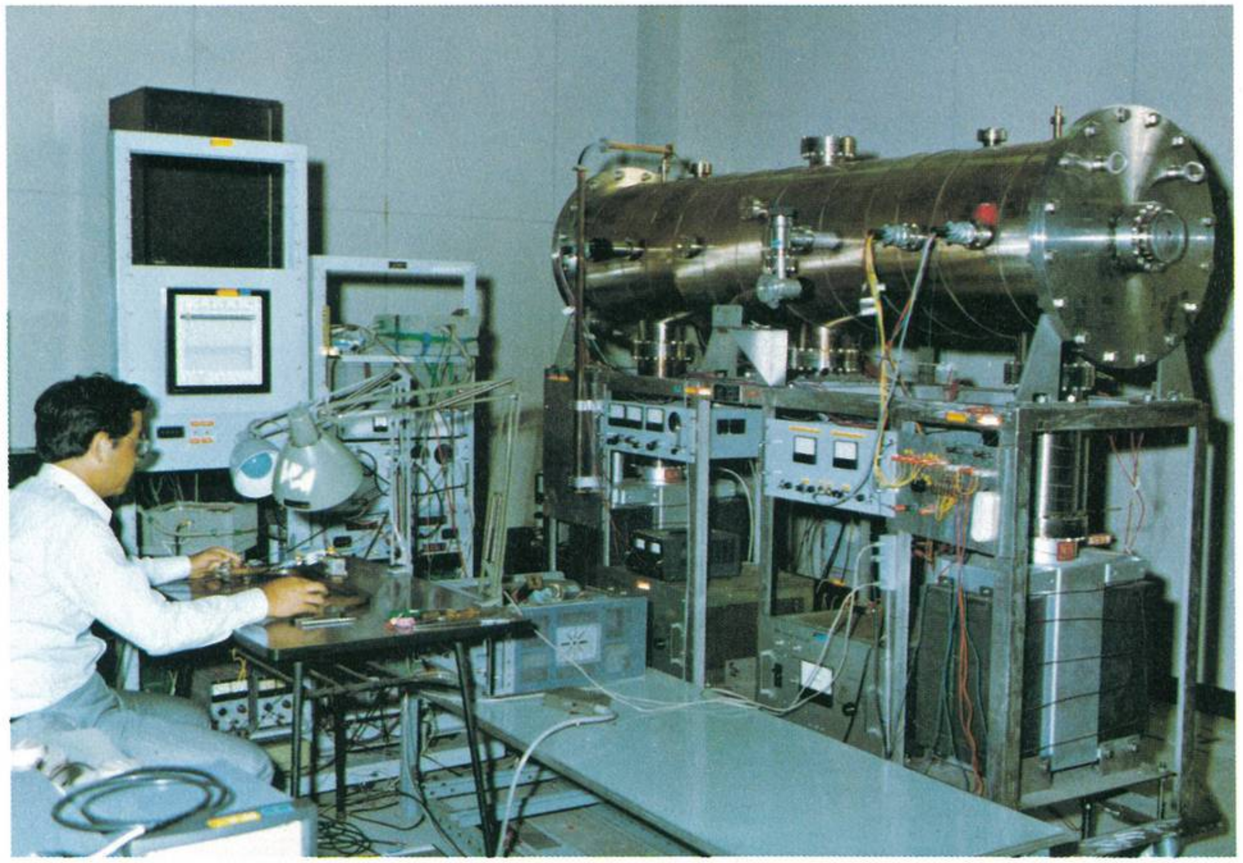
The unit of time, "Second", is defined by the resonant frequency of 9,192,631,770 Hz of Cesium atom. Researches have been made on several types of atomic frequency standards since 1951 at RRL.

Hydrogen maser type and Cs laboratory type standards are under developing in order to keep the national standard of frequency and time with high accuracy and stability by combination of these standards.

Development of H-maser type standard started in 1965, and RRL succeeded in the oscillation in 1966 as the third country in the world. By further study of the storage bulb effect on the absolute frequency value, the frequency accuracy of about 3×10^{-12} was obtained, and an international direct comparison of H-maser frequency between RRL and the NRC of Canada, using the RRL-made specific bulb, resulted in coincidence of 2×10^{-12} The short-term frequency stability of a new improved H-maser is about 6×10^{-15} for averaging time of around 100 second, and the long-term stability is about 1×10^{-14}.

With Cs standard under developing since 1976, Cs tube was constructed as well as control circuit. Now, improvement for obtaining the frequency accuracy of 1×10^{-13} is being carried out.

Hydrogen masers



Cs beam standard

RRL ATOMIC TIME SCALE AND JAPANESE STANDARD TIME

RRL is responsible for keeping the Japanese Standard Time (JST) based on the International Atomic Time (TAI).

An algorithm has been developed for determining an accurate and uniform atomic time scale, TA (RRL), using the data of intercomparisons among the primary standards and Cesium working standards.

This atomic time sclae, on which the JST is based, has been compared internationally by various methods.

Automatic data processing system for time standard determination

INTERNATIONAL TIME COMPARISON

The international comparison of atomic time scales has been made mainly via Loran-C and Omega signals, and occasionally through direct comparison with a portable clock transported from the U.S. Naval Observatory (USNO). Besides, some experiments via satellites have been performed in order to establish higher precision method.

The phase comparison, using a leading part of received pulse of 100 kHz (Loran-C Iwojima) which consists of only ground wave, makes it possible to keep the accuracy of several tenths of a microsecond. As to the Omega, receptions of signals from stations of Hawaii (11.8 kHz and 13.6 kHz) and Japan (13.6 kHz) are being made. An accuracy of a few microseconds can be obtained in the time comparison through VLF technique.

The experiment via Navigational Technology Satellite (NTS-1) was conducted from Oct. 1978 to Sept. 1979. Phase measurements of received side tones of ten kinds, from 100 kHz to 6.4 MHz, transmitted by the carrier of 335 MHz, were made a few times a day. With this system, the accuracy better than 1 microsecond was obtained in the time comparison between RRL and USNO. In the near future, the accuracy of one tenth of a microsecond can be expected via the Global Positioning System (GPS).

Timing receivers for Loran-C, Omega and NTS

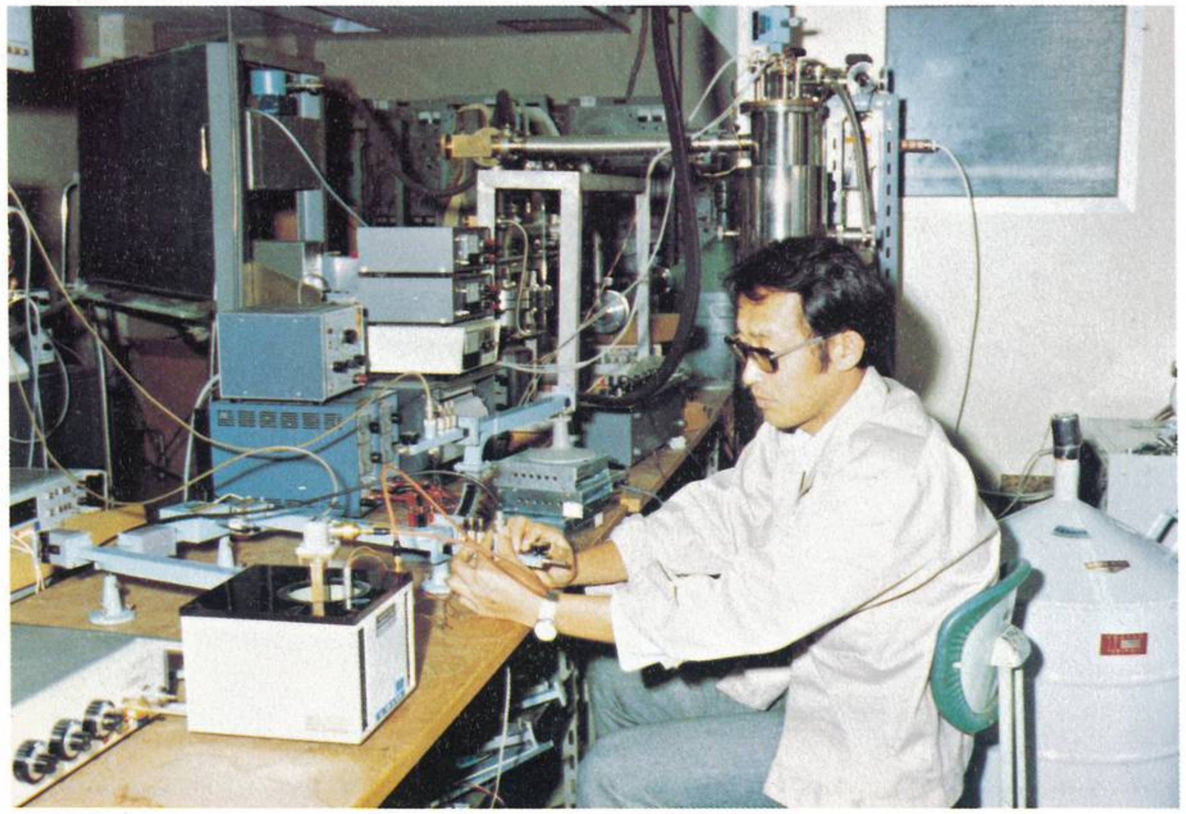
PRECISION MEASUREMENT OF FREQUENCY STABILITY

Experiment of a superconducting cavity stabilized oscillator (SCSO) has been made since 1977 for the primary purpose of obtaining an extremely stable active reference of the stability measurement. In this experiment, frequency of an X-band Gunn diode oscillator is stabilized with a superconducting niobium (Nb) cavity resonator.

Until now, unloaded Q of 10^7 has been obtained at the temperature of 4.2 K for the resonator in TM_{010} mode at 9.2 GHz, processed by chemical polishing only. The short-term stability of the SCSO using this resonator attains about 2×10^{-11} for the averaging times of several seconds.

In order to improve the Q of the resonator, namely, to improve the short-term stability of the SCSO remarkably, heat treatment of the cavity in ultra-high vacuum at about 2000°C is now in progress in addition to the chemical polishing.

Besides the application to the measurement of frequency stability, the SCSO can be used for the study of atomic frequency standards, for the signal source of the frequency multiplication up to the light frequency region, and for a local oscillator in very long baseline interferometry (VLBI) system in the future.



Experimental apparatus of SCSO

DISSEMINATION OF TIME AND FREQUENCY VIA SATELLITE

The preparation of an experiment of time and frequency dissemination by the synchronizing pulse and color subcarrier in TV signals from BSE has been carried out. This method is considered to be a very promising one because every user at any place in the country can get time and frequency calibration of high accuracy by just attaching a fairly simple calibrating apparatus to their own TV receiver, if the Doppler shift in frequency and time can be canceled sufficiently.

Preliminary experiment recently made has proved that the Doppler frequency shift can be corrected to the order of 10^{-11} by using the predicted values of orbital position of the BSE, and that the short-term frequency stability of the color subcarrier as received was comparable to that in the terrestrial TV broadcasting.

To establish the technique of time and frequency comparison of very high accuracy of picosecond order, an experiment using the CS is carried, in which the effects of the ionosphere and the troposphere on the accuracy of time comparison is examined using C-band and K-band carriers modulated by the ranging signals of PRN code.

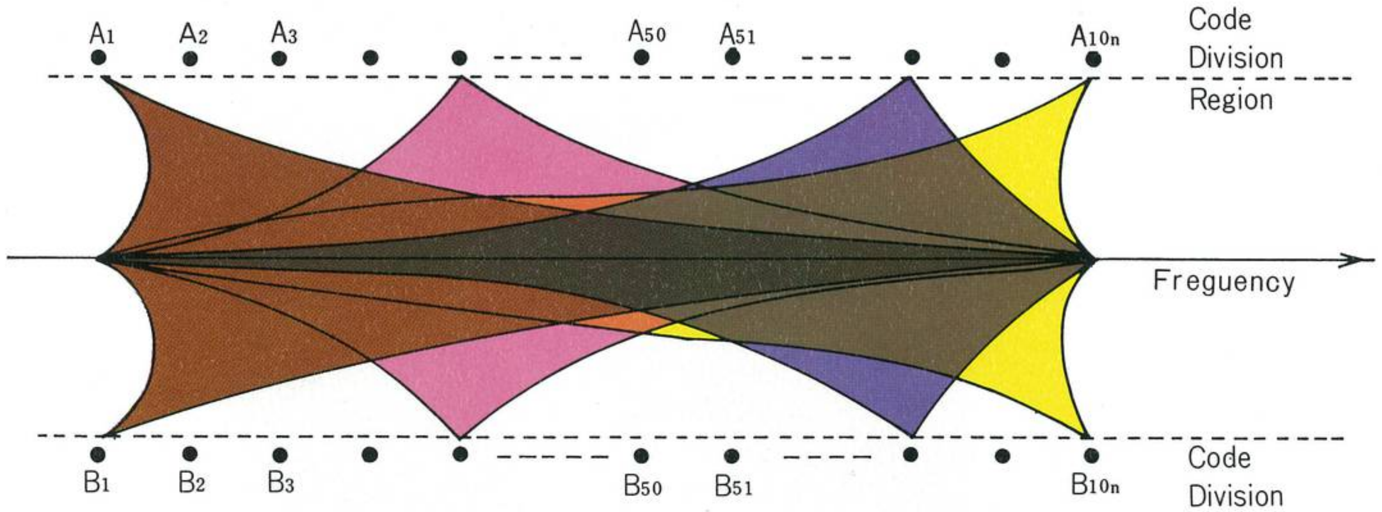
BSE receiving system and time and frequency measuring system

APPLICATION OF SPREAD SPECTRUM TECHNIQUES

The features of spread spectrum techniques are: 1) large interference rejection capability, 2) low-power density transmission, 3) message privacy, 4) selective addressing, 5) selective fading rejection, and 6) possibility of frequency sharing in the same band.

The spread spectrum system is highly efficient and reliable under the line-of-sight communication condition, but the applicability of this system to the land mobile radio communication is unknown, especially, in consideration of the loss of synchronization under the rapid variations of both signal level and phase caused by many reflected waves from buildings.

In order to establish the land mobile spread spectrum systems under these unfavorable conditions the research has started as a five year project. During the former half, the basic spread spectrum systems with flexibility are investigated by using the wideband fading simulator, and during the latter half the applicable systems are proposed.



Spread spectram system

APPLICATION OF LINCOMPEX SYSTEM

As an extension of the existing maritime Lincompex system in MF and HF bands, a 150 MHz Lincompex system with a bandwidth of 3 kHz has been developed in order to overcome deep and rapid fading occurring in the land mobile communication. Field tests by a running vehicle were carried out in the metropolitan area. Speech quality of this Lincompex system is hardly affected by fading as compared with the SSB system without Lincompex, and the protection against city noise is almost the same as that of the existing FM system. For the adjacent signal selectivity, the minimum channel separation of about 6 kHz was obtained in the laboratory test.

Land mobile Lincompex equipment

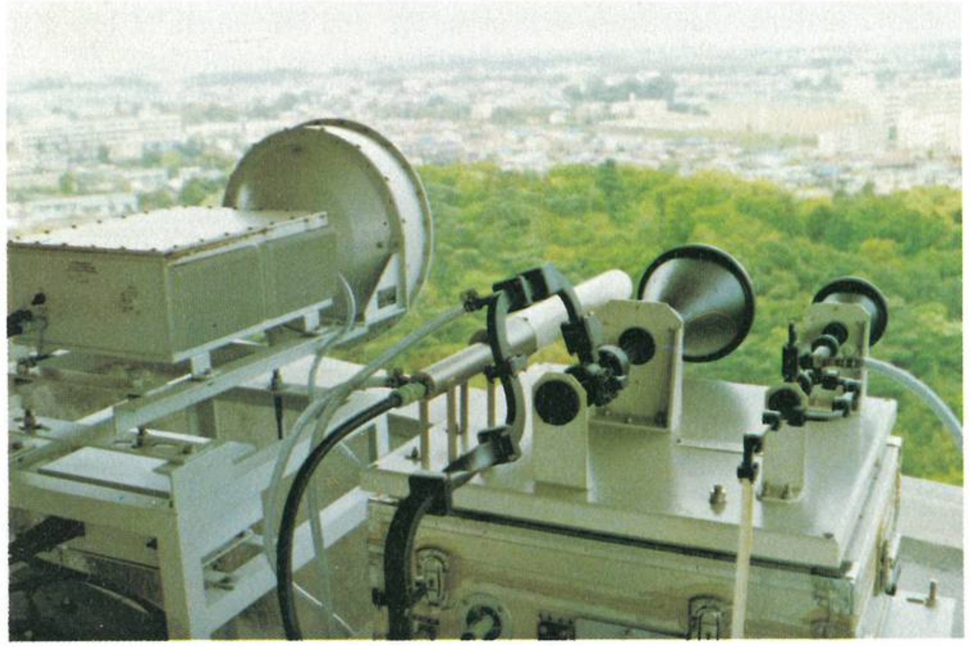
INTERFERENCE PREDICTION BY MODELLING

A statistical treatment by computer simulation is used in the interference prediction method. The statistical models, such as propagation, external noise, and operation models, are made up by the distribution functions of each model, which are characterized by their mean values and standard deviations.

On the channel separations of 12.5 kHz and 25 kHz in FM systems, both receiver characteristic models and statistical models of communication traffic have been developed on the basis of the measured results, rather than on the basis of theoretical analysis.

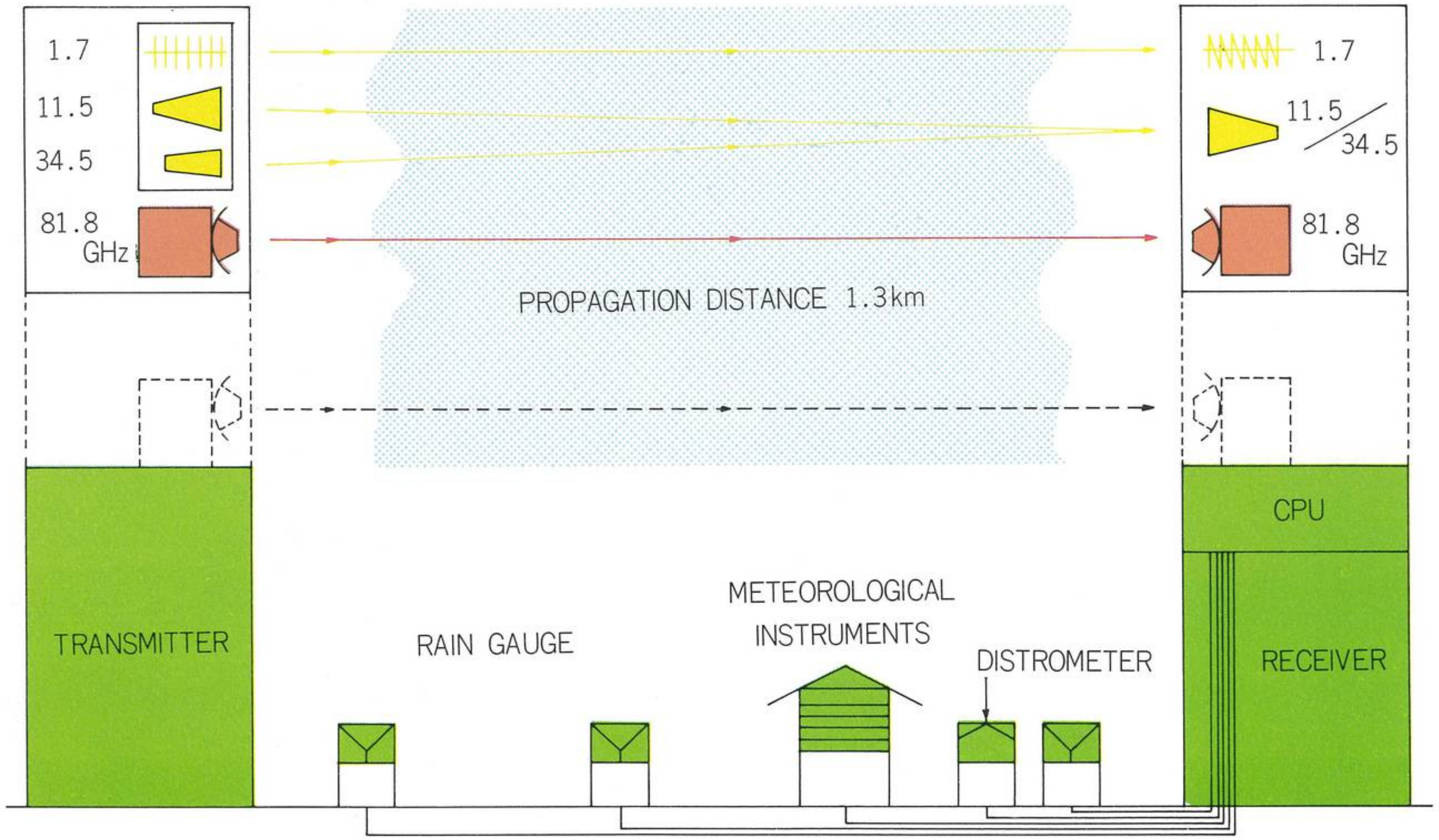
MILLIMETER WAVE PROPAGATION EXPERIMENT

Development of new frequency bands which are more than 40 GHz is of potential importance, for meeting the strong demand for communication and variety of communication methods due to the increase of recent social activity, for application of radio wave to the meteorology, and for utilization of electromagnetic wave energy. One of the most important things to develop the utilization of these new frequency bands is to clarify rainfall effects on these radio waves propagation. For this purpose, mm- and cm-waves propagation experiments have been conducted since April, 1979 by using the multichannel transmitter and receiver system whose signals are originated from a single crystal oscillator.



Transmitting antenna system
(left to right) 81.8 GHz Cassegrain, 1.7 GHz cross dipole, 11.5 GHz horn and 34.5 GHz horn antennas

OUTLINE OF MILLIMETER WAVE EXPERIMENT SYSTEM



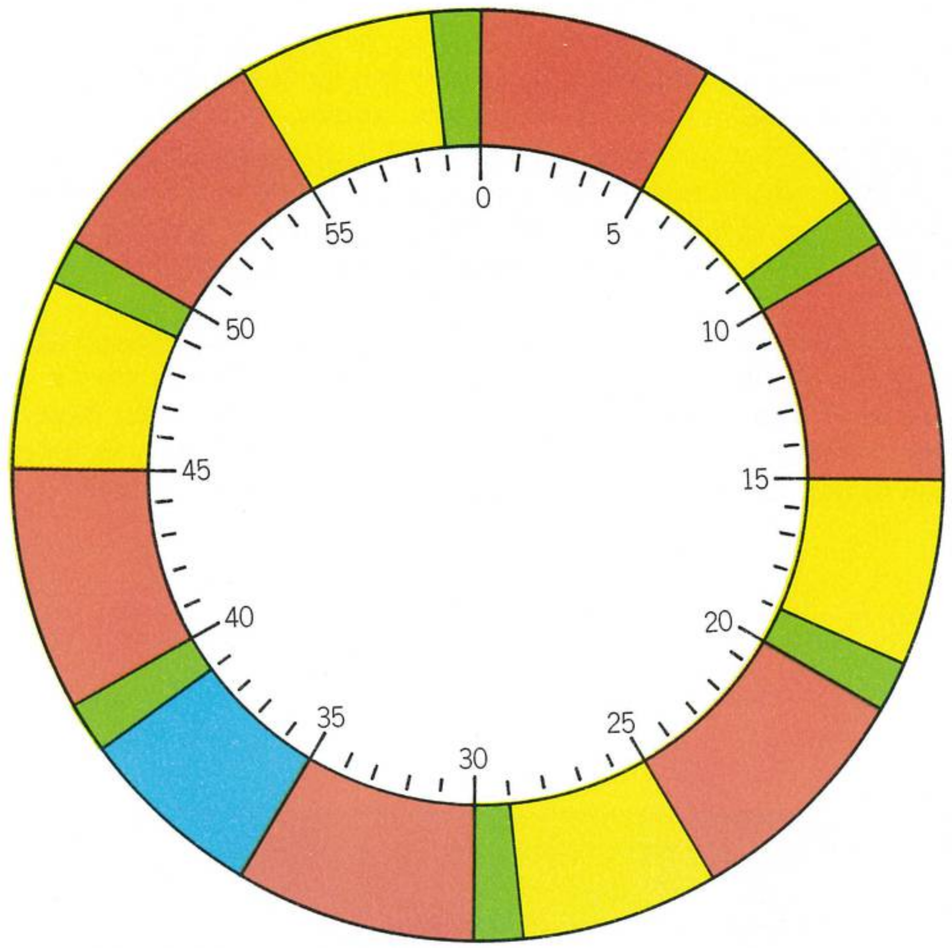
Receiving antenna system (top to bottom)
1.7 GHz helical, 11.5/34.5 GHz offset paraboloidal and 81.8 GHz Cassegrain antennas

STANDARD FREQUENCY AND TIME BROADCAST SERVICE

The standard frequencies and time signals are continuously broadcast for users in many fields from JJY and JG2AS stations at HF and LF, respectively. The transmitted frequencies are maintained within $\pm 1 \times 10^{-11}$ in accuracy with respect to the value determined by the international definition of the second. The JJY time-signals are based on the UTC system and synchronized internationally within ±1 ms.

JG2AS has been used especially for high precision frequency calibration because of more stable propagation characteristics compared with HF wave.

The new remote-controlled stations, located about 60 km from the RRL Headquarters, have been operated since the end of 1977.



JJY hourly broadcasting schedule

Stations for standard-frequency and time-signal

Call sign	JJY	JG2AS (JJF–2)
Frequencies	2.5 MHz, 5 MHz, [redacted] 10 MHz, 15 MHz	40.0 kHz
Antenna power	2 kW	10 kW
Operation hours	24 hrs	
Pulses of second	Continuous	Continuous in absence of telegraph message (JJF–2)
Accuracy	$\pm 1 \times 10^{-11}$	
Location	Nazaki radio station, Sanwa, Ibaraki (36° 11′N, 139° 51′E)	

.... 1,000 Hz modulation

.... Non-modulation

.... No emission

.... Station announcement

IUWDS INTERNATIONAL URSIGRAM AND WORLD DAYS SERVICE

The International Ursigram and World Days Service network has been effectively operated since the IGY for the rapid exchange of solar and geophysical data for researchers and observatories. In general, the IUWDS message, the so-called URSIGRAM, contains two kinds of information: one is the solar and geophysical data, such as solar activity, geomagnetism, cosmic rays, ionosphere, etc, the other is "PRESTO" (prompt report of major events), "GEOALERT" (Geophysical alert), etc. These messages coded in five-digit numbers are defined in the code book released by the IUWDS WWA (World Warning Agency). The system of the IUWDS is divided into five regions in the world, each of which has Regional Warning Center (RWC). The Western Hemisphere RWC at Boulder, U.S.A. serves as the IUWDS WWA.

RRL has been designated as the Western Pacific RWC since the establishment of the International Geophysical Year (IGY) in 1957, and the URSIGRAM in the Western Pacific Region has been exchanged with the four other RWC's (Boulder, U.S.A.; Moscow, U.S.S.R.; Paris, France; Sydney, Australia), and also, URSIGRAM broadcasting has been put into operation in order to provide the IUWDS information to scientific researchers and observatories in the same region.

URSIGRAM broadcasting is outlined as follows:

Communication center: RRL, Koganei, Tokyo
Transmitting station: Usui, Chiba Pref.
(35° 43.7′N, 140° 12.2′E: about 60km east of RRL)

Current broadcasting schedule

Call sign	Frequency (kHz)	Class of emission	Time (UTC)	Power (kW)	Antenna
JJD	10,415	A1	08:00	5	Non-directional
JJD2	15,950	A1	08:00	5	Non-directional

WORLD DATA CENTER C2 FOR IONOSPHERE

The World Data Centers were established by the Special Committee for the IGY (International Geophysical Year) under the ICSU (International Council of Scientific Unions), with the view of collecting, keeping and re-distributing geophysical and solar data on a world-wide basis long after the IGY.

The World Data Centers are as follows:

Center A :	All disciplines	U.S.A.
Center B :	All disciplines	U.S.S.R.
Center C :	Single discipline	Several nations

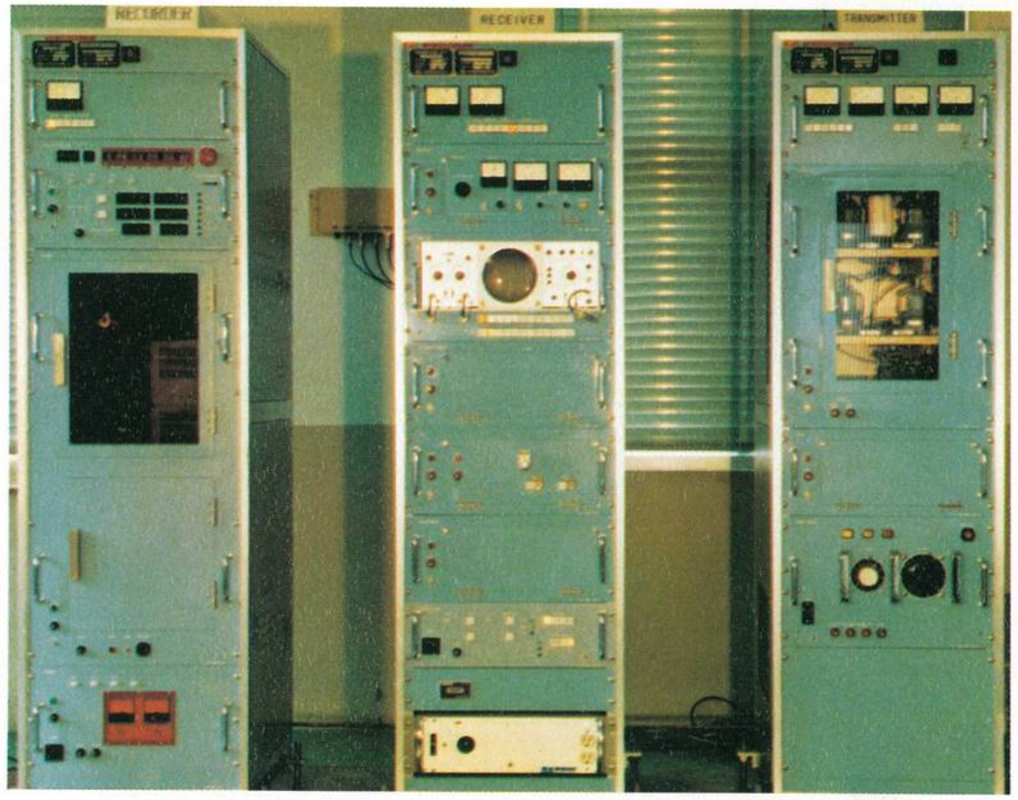
Also, WDC C2 for Ionosphere was organized at RRL in 1958, and has been operated in the Technical Service Section, Planning and Support Division.

Categories of the data collected for about 20 years at the C2 Center are Ionosphere Vertical Soundings, Topside Vertical Incidence Soundings, Total Electron Content, Absorption (Methods-A1, A2 and A3), Ionospheric Drifts, Ionospheric Back-scatter, Whistlers and VLF Emissions, Atmospheric Radio Noise, etc. At present the C2 Center keeps a large quantity of ionospheric data sent from many observatories mainly in Asian and Oceanian regions, and exchanges regularly above data with other Centers in accordance with the Guide.

Room for shelf-keeping of ionospheric data

BOTTOMSIDE IONOSPHERE SOUNDINGS

Observations of the ionosphere by means of vertical sounding techniques are being made at the Radio Wave Observatories of Wakkanai, Akita, Kokubunji (the RRL Headquarters), Yamagawa and Okinawa, located from north to south at intervals of about five degrees of latitude nearly along the 135°E longitude, and also at the Syowa Station (69.0°S, 39.6°E), Antarctica, in cooperation with activities of the international scientific communities, on routine basis. It should particularly be mentioned that ionospheric soundings in the Tokyo district started in 1932 at about the same time as in the U.S.A. (Washington, D.C.) and England (Slough). The results of ionospheric observations give not only the most important information on ionospheric radio propagation conditions but also the data which are very contributory to investigations of physical properties of the ionosphere itself. According to the URSI rules, ionospheric observatories are requested to make vertical sounding normally every 15 minutes on a routine basis. Ionospheric parameters obtained at the five Japanese sounding stations are published monthly in the " Ionospheric Data in Japan" for distribution among the World Data Centers as well as domestic and foreign agencies concerned.



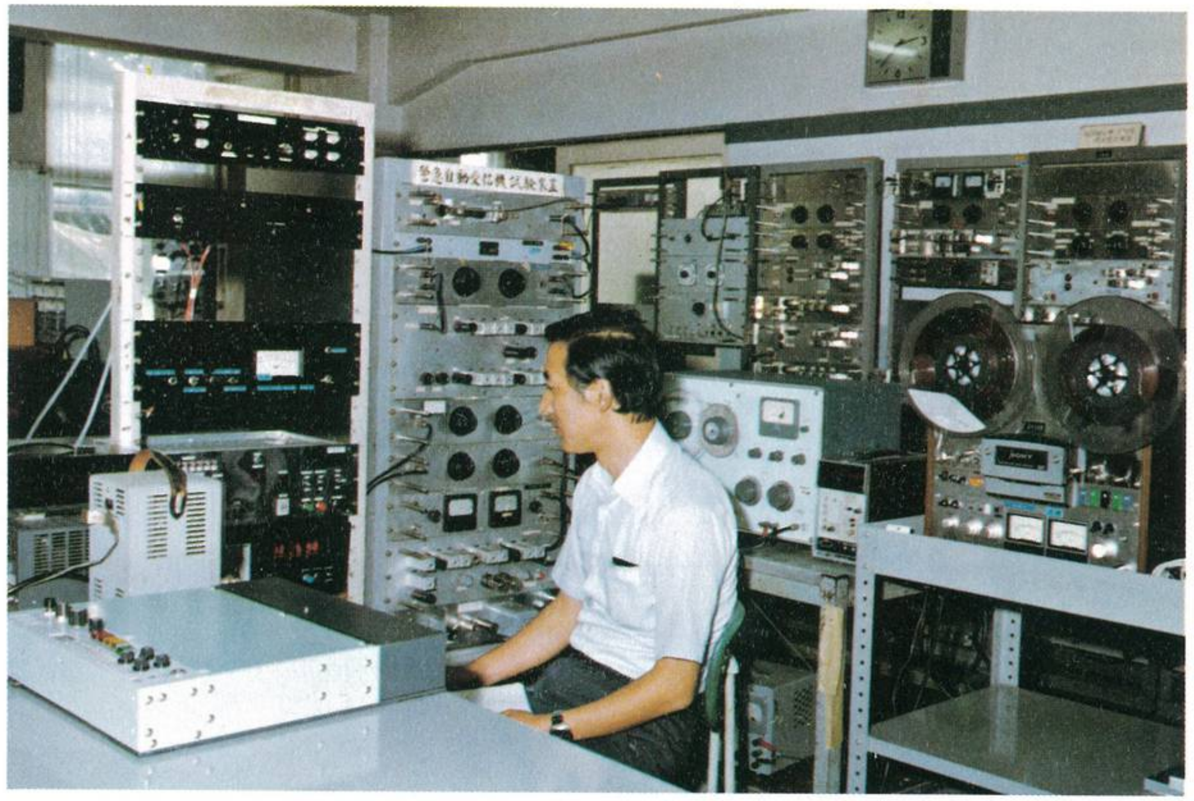
Ionosonde (Type 9–B)

TYPE APPROVAL TEST, PERFORMANCE TEST AND CALIBRATION

The following radio equipments used at radio stations are legally subject to the type approval of RRL. They are frequency meters, radio direction finders, marine radars, portable radiotelegraph for lifeboat, transmitters and receivers for aircraft, and automatic alarm signal receivers which are used for the safety of navigation.

Additionally, in order to maintain the technical standards, the followings are recommended to pass through the test of type approval. They are radio sondes, radio buoys, radio equipments for emergency position indicating radio beacon, miniaturized TV-translators, single sideband transceivers, radio equipments for mobile service, and radio transceivers in citizen bands.

RRL conducts the performance test of radio equipments and the calibration of measuring equipments in response to the requests from the public.

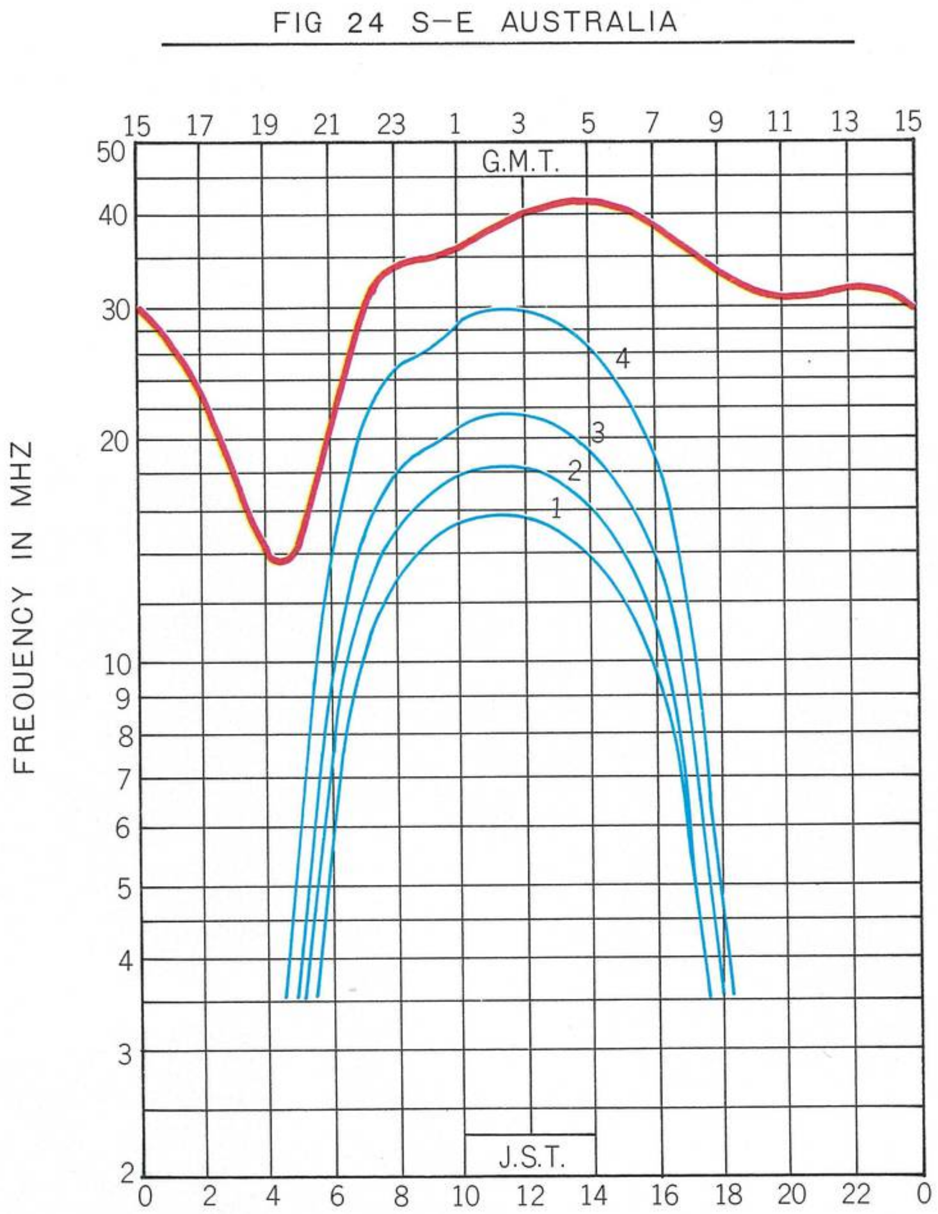


Type approval test scene

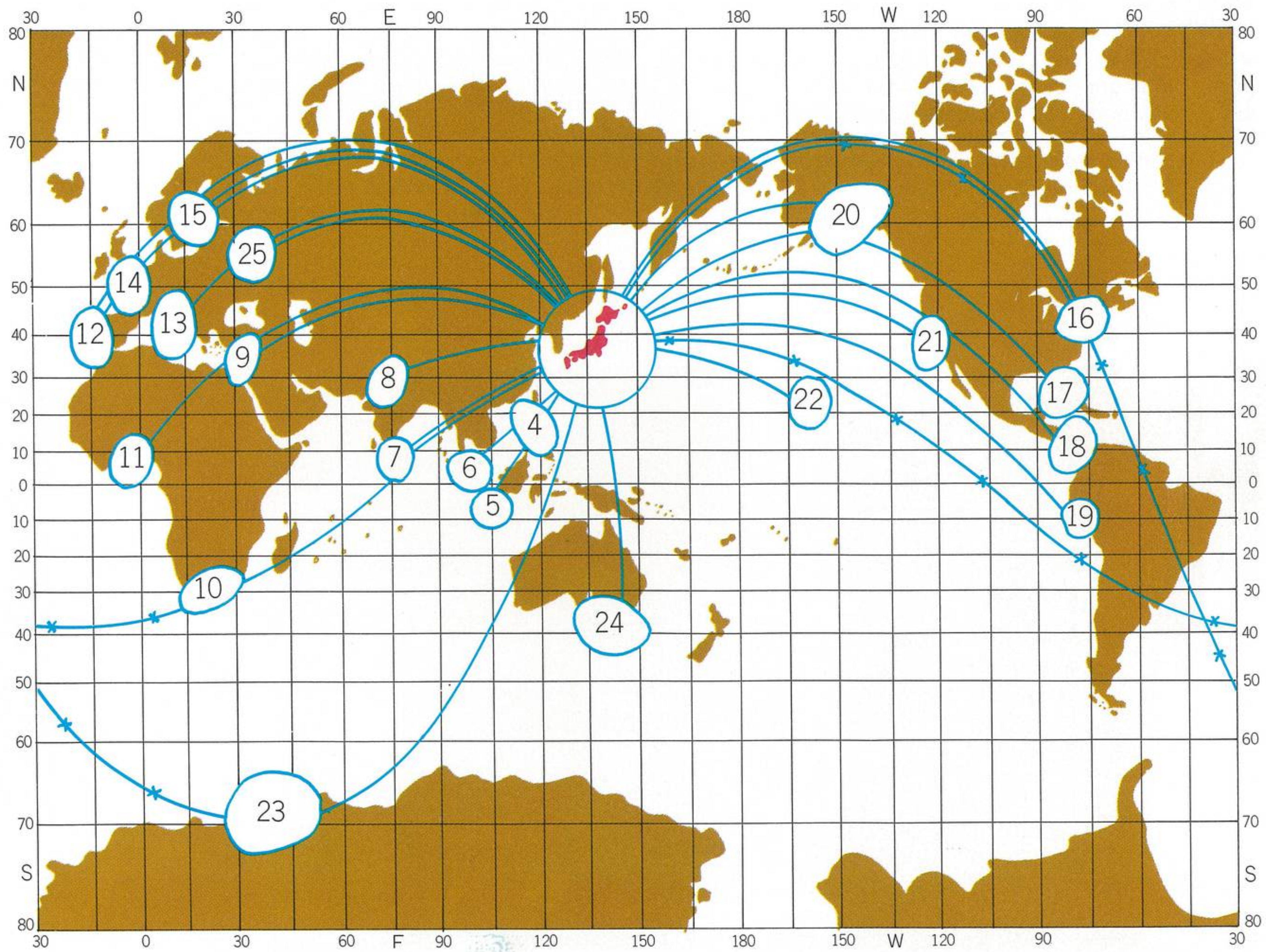
HF RADIO PROPAGATION PREDICTION SERVICE

The long-term (monthly) radio propagation prediction as to HF circuit MUF (maximum usable frequency) and LUF (lowest usable frequency) follows usually the CCIR interim or revised interim method. RRL issues monthly three months in advance the HF radio propagation prediction which is made for radio communications between Tokyo and each of the several districts as well as the waters where merchant or fishing vessels are on voyage. The prediction diagram prepared by the full use of an electronic computer gives an idea of operational frequencies usable for communications between two places at a given time.

Recently, the short-term (weekly) radio propagation prediction was successfully tried by means of the sounding data from Ionosphere Sounding Satellite (ISS-b) and terrestrial ionosphere observatories.



Monthly radio propagation prediction as to MUF and LUF



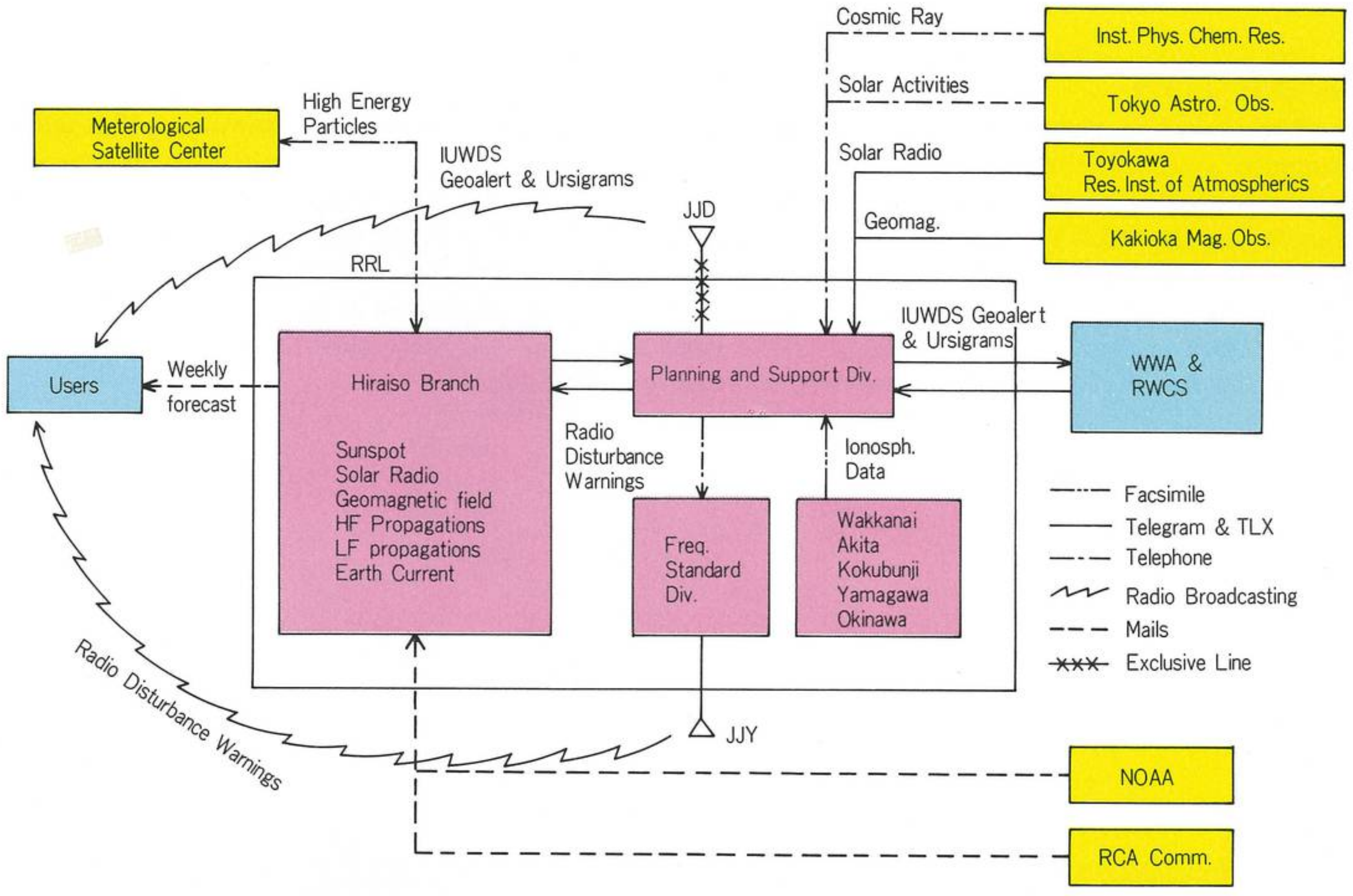
Service area of monthly radio propagation prediction

RADIO DISTURBANCE WARNINGS

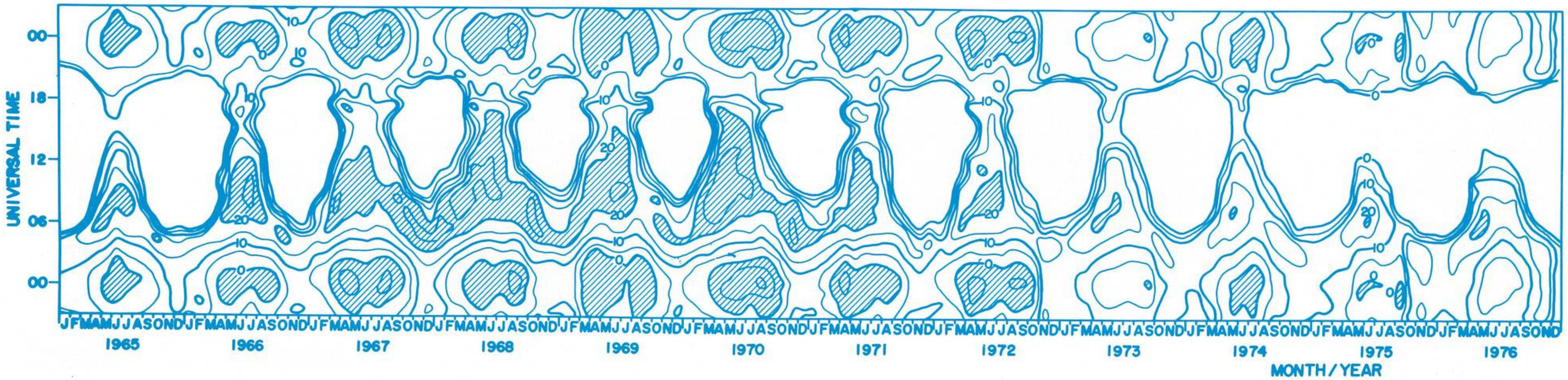
HF radio communications are sometimes interrupted in association with solar and geophysical disturbance phenomena such as solar flares and geomagnetic storms. RRL predicts such radio disturbances, and provides warnings to communication engineers and other users as a guide for their plannings and operations. In addition, daily predictions of solar flares and geomagnetic storms are made and issued as GEOALERT messages in the program of the International Ursigram and World Days Service (IUWDS).

The Hiraiso Branch of RRL collects prompt data required for these predictions from its own sensors, other observatories of RRL, cooperating agencies and institutions, and foreign countries through the IUWDS data exchange network. Listed below are the principal real-time data available at Hiraiso: 1) sketches of sunspot regions, 2) solar radio emissions at 100, 200, 500 and 9500 MHz, 3) magnetograms and earth current records, 4) electric field strength data of HF radio signals on various long-distance propagation circuits, 5) MUF and LUF variations by a chirp-sounder, and 6) high-sensitive SID detection by Loran-C observations.

Recently, a new solar radio observation system has been developed, which provides the radio intensity maps of the sun and the temporal variations in radio intensity from particularly active centers on the solar disc at the frequency of 32 GHz. It is expected that this system will bring about some important progress in solar physics and also in solar flare prediction techniques.



Radio disturbance warning services



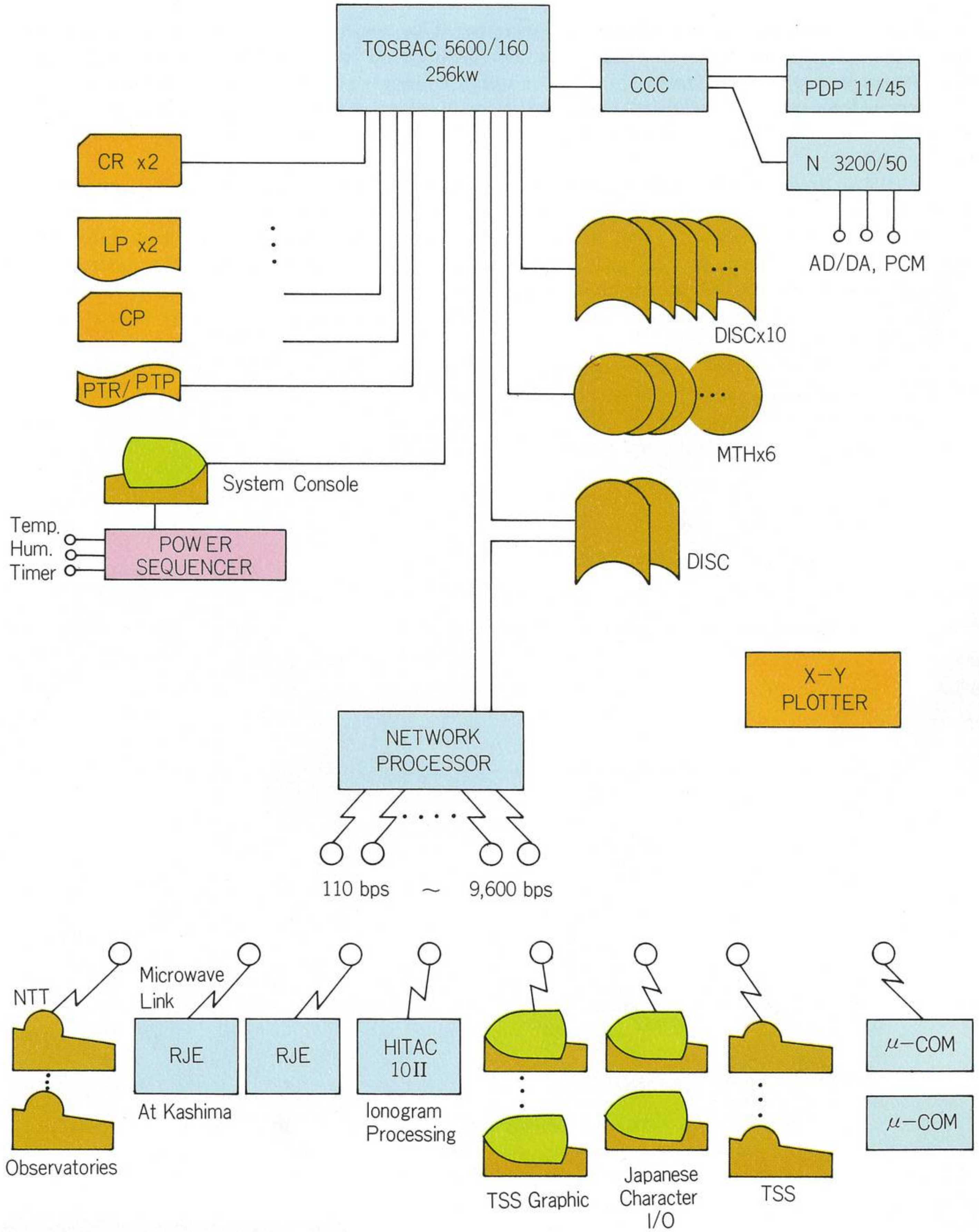
Contour map of electric field strength of WWVH 15MHz wave

COMPUTER SYSTEM AND ITS OPERATION

For extensive activities in all fields at RRL, the TOSBAC 5600/160 and its additional facilities were provided in 1975.

The operation system of TOSBAC 5600 is GCOS. It has multidimensional capabilities. This main computer system is able to not only perform the central batch processing but also carry out the remote operations with the aid of RJE (remote job entry) and TSS (time sharing system). RJE subsystems are installed at the RRL Headquarters and the Kashima Branch, and TSS subsystems are installed at the Hiraiso Branch and five Radio Wave Observatories at Wakkanai, Akita, Inubo, Yamagawa and Okinawa, in addition to the above two places. Furthermore, the minicomputers such as NEAC 3200/50 and PDP 11/45 which are set up at the vicinity of the main computer, are connected to the main computer system through the high speed computer communication controller.

Main computer room

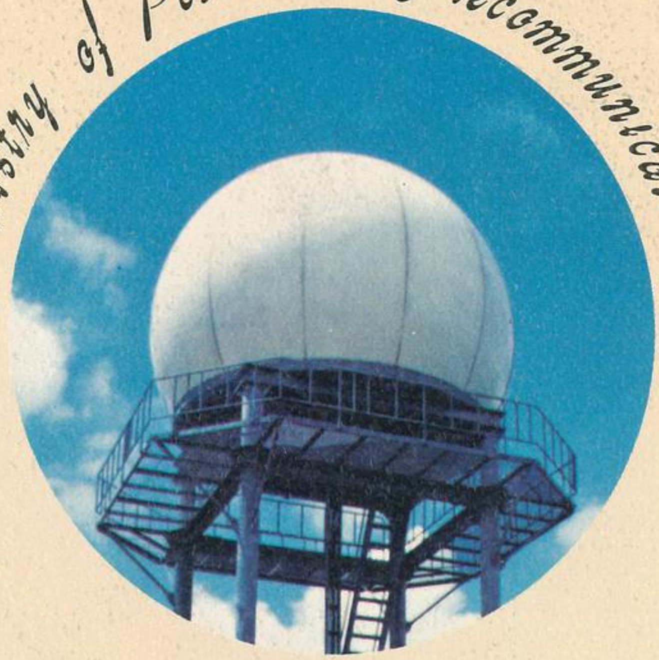


Outline of main computer system

PUBLICATIONS

1.	RRL News (in Japanese)	Monthly
2.	Monthly Radio Propagation Forecast (in Japanese)	Monthly
3.	Ionospheric Data in Japan	Monthly
4.	Standard Frequency and Time Service Bulletin	Monthly
5.	Review of the Radio Research Laboratories (in Japanese)	Quarterly
6.	Journal of the Radio Research Laboratories	Thrice a year
7.	Ionospheric Data at Syowa Station (Antarctica)	Semi-annual
8.	RRL Annual Bulletin (in Japanese)	Annual
9.	Catalogue of Data in World Data Center C2 for Ionosphere	Annual
10.	Radio and Space Data	Irregular
11.	Data on Topside Ionosphere	Irregular

Publications



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