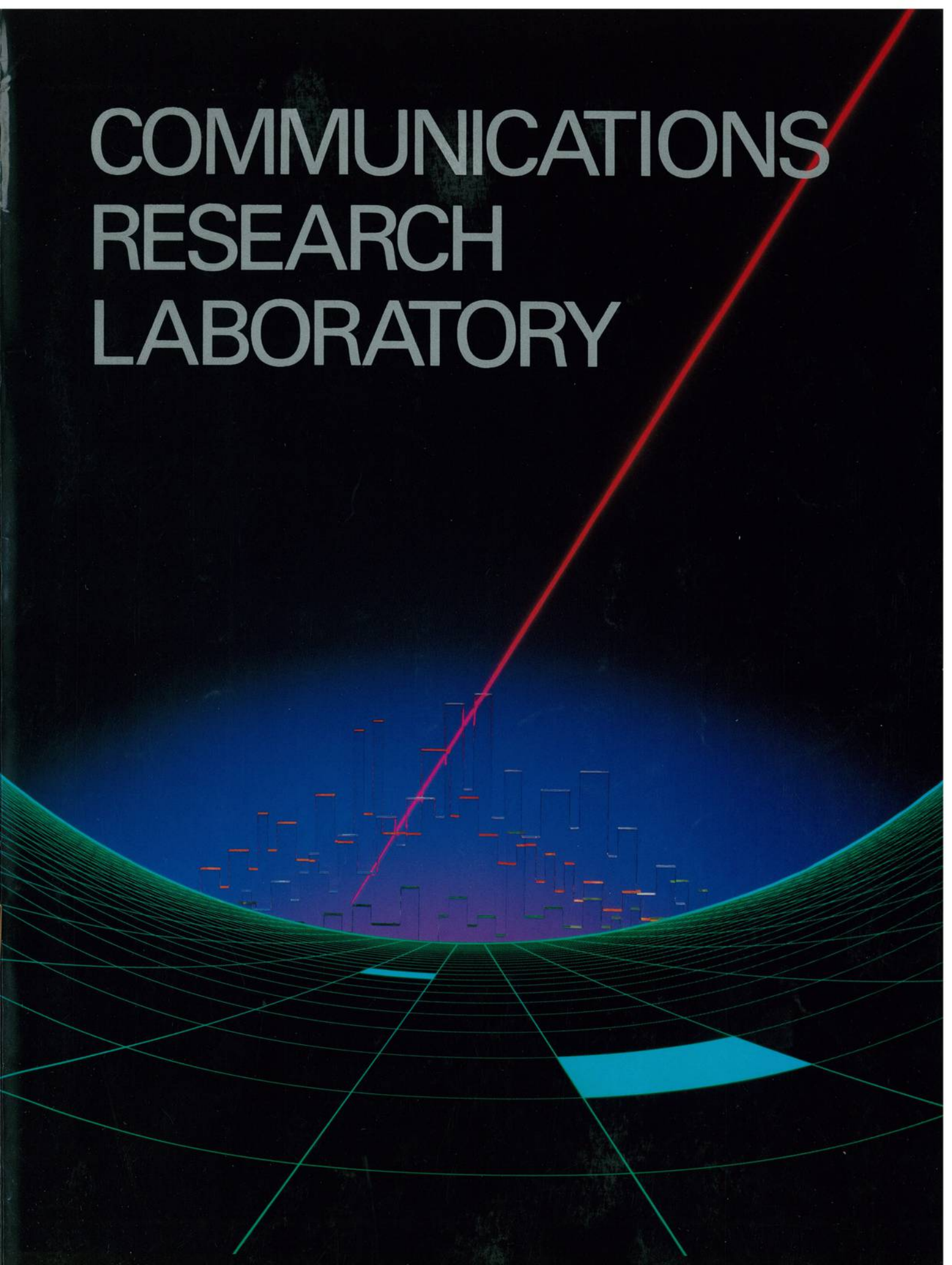
COMMUNICATIONS RESEARCH LABORATORY



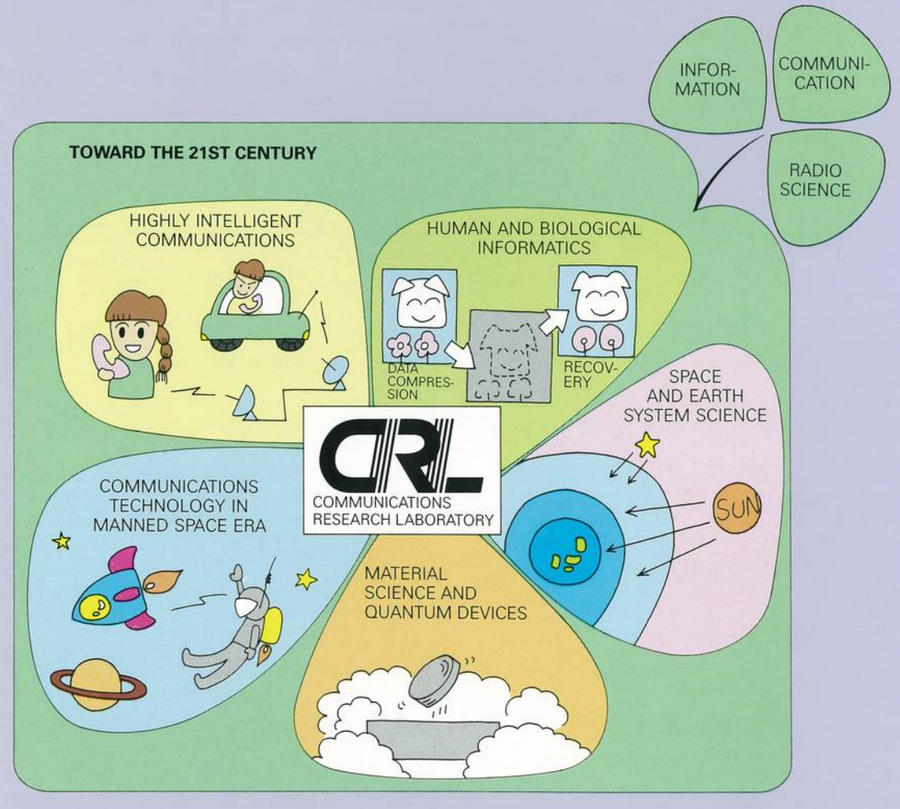
Ministry of Posts & Telecommunications Japan 1988

OUTLINE OF COMMUNICATIONS RESEARCH LABORATORY

Communications Research Laboratory (CRL) of the Ministry of Posts and Telecommunications, the name of which was changed from Radio Research Laboratory (RRL) in April 1988, is the only national research institute for telecommunications technology, radio science, and radio applications in Japan. The activities of CRL date back to 1896, and in accordance with social demands, various research such as in radio science and applications, space communications, space science, and atmospheric science were carried out in the name of RRL. In 1988, the laboratory made a restart as an integrative research institute engaged in both basic and applications research with the name CRL.

The organization, as well as coverage and levels of research has changed extensively. For example, in April 1985, the laboratory was fully reorganized to meet the requirements of a modern information-intensive society. Currently, the organization consists of nine divisions, three special research offices, two research centers and five radio wave observatories (See next page). CRL has a staff of 424 people and an annual budget of 4.2 billion yen in 1988.

CRL took up the following five research fields in view of the communication demands and radio utilization in the 21st Century.



ORGANIZATION OF COMMUNICATIONS RESEARCH LABORATORY

April, 1988

Director General
Deputy Director General
Associate Director General

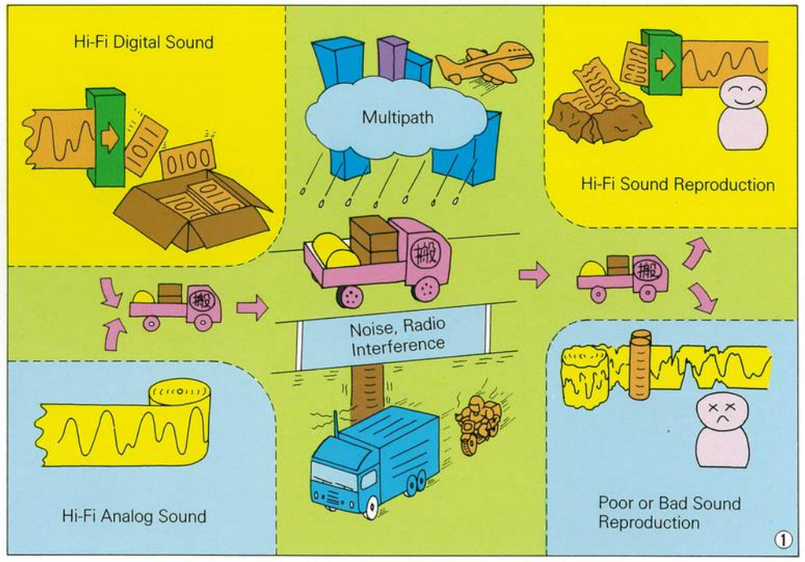
Administration Division	General Affairs Section Accounts Section
Planning Division	Planning Section International Affairs Section Technology Assessment Section
Technical Information Division	Information Management Section Computer Center Ionospheric Observation Section
Telecommunications Division	Communication Network Research Section Computer Communications Research Section Communication Performance Research Section Broadcasting Technology Research Section Electromagnetic Compatibility Research Section
Space Communications Division	Satellite Communications Section Mobile-Satellite Communications Section Space Technology Section Space Communication Sytems Section
Communication Technology Division	Speech Research Section Image Processing Research Section Digital Communications Research Section Antenna Research Section Applied Radio Physics Section
Radio Science Division	Magneto-Ionospheric Propagation Section Atmospheric Propagation Section Radio Propagation Media Section
Application Division	Remote Sensing Research Section Optical Applications Research Section Space Environment Research Section Radio Applications Research Section
Standards and Measurements Division	Atomic Standards Research Section Frequency and Time Measurements Research Section Radio Measurements Research Section Frequency and Time Standards Section Calibration and Type Approval Section
Office for Space Science	
Office for Atmospheric Radio Science	
Office for Radio Physics	
Kashima Space Research Center	Administration Section Satellite Control Section Radio Propagation and Remote Sensing Section Space Communication Applications Section Applications Section
Hiraiso Solar Terrestrial Research Center	Radio Disturbances Prediction 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

高機能知的通信の研究

HIGHLY INTELLIGENT COMMUNICATIONS

The role of telecommunications in modern information-intensive societies is increasing rapidly. In order to realize the ultimate form of communication, "whoever can obtain whatever information one wants at whenever and wherever," various basic and practical research in telecommunications has been carried out. This research field includes applications of artificial intelligence, human-interface, information and signal processing in communications technology, and exploration of new frequency bands for communications.

Current research involves high performance integrated networks including satellite networks, digital signal processing technology for high quality communication and broadcasting, utilization of higher frequency bands for land mobile communication, and techniques for measuring the electromagnetic environment.

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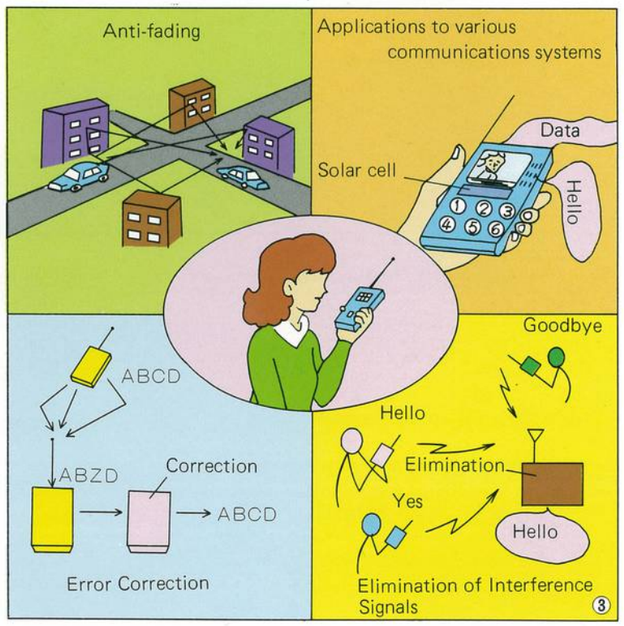


① High Quality Digital Sound Broadcasting System

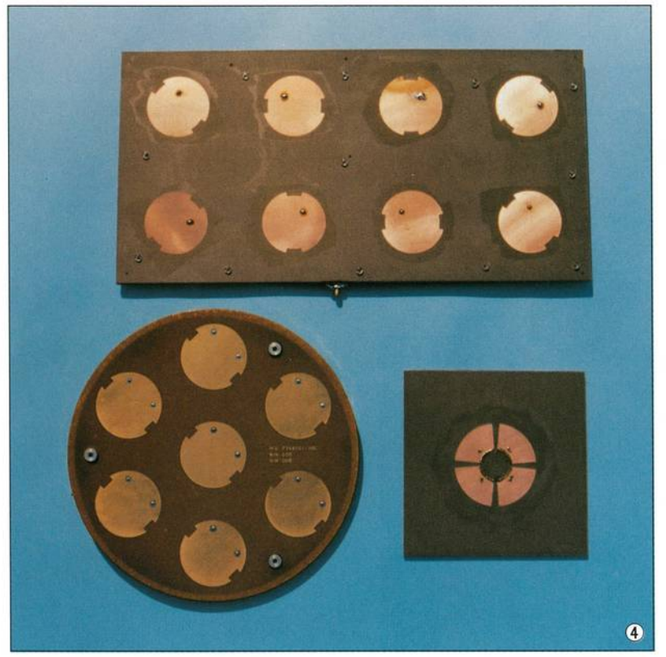
Sound quality on the air is degraded by such disturbances as multipath, noise, and interference. In this sytem, the degradation is removed and the original high quality sound is reproduced.

② Measurement of the Electromagnetic Environment

For studying the electromagnetic environment, the characteristics of radio noises generated by electronic devices have been investigated. The levels of power flux density radiating from emitters have been surveyed in urban areas by using a specially developed system.

③ Digital Mobile Communication System

A digital modulation system can realize encrypted voice communication and can directly access a computer data base. The efforts of researchers are focused on the development of key techniques such as error correction and adaptive equalization technique for anti-fading, elimination technique of voice coding, and modulation for effective use of the frequency spectrum.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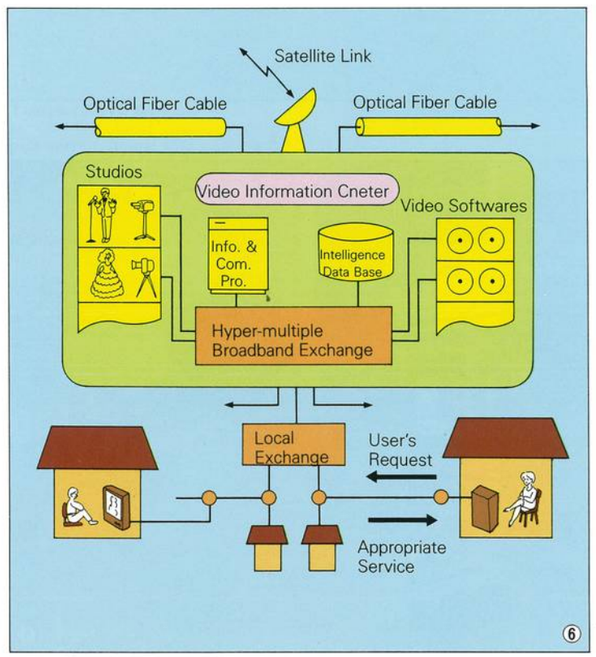
④ Planar Antenna

Basic research and development of planar antennas, exploiting advantages such as low volume, light weight, and low profile, are being conducted. ① Satellite-borne array antennas, ② airborne array antennas and ③ mobile communications antennas have been developed so far. The research will be continued in order to develop planar antennas for millimeter wave communication and microwave power transmission. Furthermore, CRL is starting basic research on a superconducting array antenna.

⑤ Investigation of Quasi-Microwave Land Mobile Propagation

To cope with large demands for land mobile radio, the development of a new frequency band, quasi-microwave region (1 to 3 GHz), is required. Experimental studies of propagation characteristics are being conducted.

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⑥ Advanced Telecommunications Network Architecture

Aiming at wideband video communication services to millions of subscribers, control software for broadband exchanges is being studied. Also, in order to realize advanced networks with artificial intelligence technology, research is being pushed forward concerning suitable computer languages and protocols for network self-rearrangement functions headed by users' requests.

人間・生体情報の研究

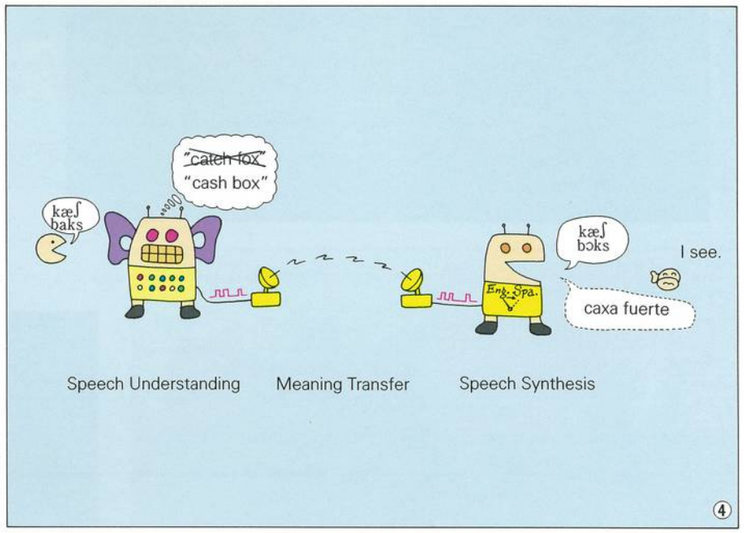
HUMAN AND BIOLOGICAL INFORMATICS

Recent progress in life science has revealed the functions of the human brain and elaborate biological mechanisms, especially in bio-molecules and cells. We think it possible to realize innovative information and communication technologies by introducing these biological excellences.

Based on this belief, we have started basic research on applications of biological functions and mechanisms in information processing and electronic materials and devices.

In the research on information processing, we are studying the functions of human sight and hearing. By applying these functions, we are also studying highly efficient coding methods for picture and voice.

In addition, in the research aimed at future bio-chips and devices, one focus is on bio-material physics including, for example, the mutual interaction phenomena between bio-material and electromagnetic waves.



①②③ Image Data Compression Techniques

Data compression techniques, to encourage the wide use of visual information communication are being studied. There are two methods, reducing data redundancy and removing information which humans cannot perceive. One method saves picture quality. The other, though decreasing quality, has a very high compression ratio.

④ Toward Future Speech Processing

A speech processing technique for speech understanding and synthesis is needed for realizing flexible human interface and for developing efficient methods for intention transfer. The current research projects of the speech research section are: (a) segmentation and phoneme identification by introducing a neural network technique together with recent signal analysis techniques, and (b) detection and understanding of hidden meanings by employing a knowledge processing technique.

⑤ Nondestructive Measurements of a Biological System

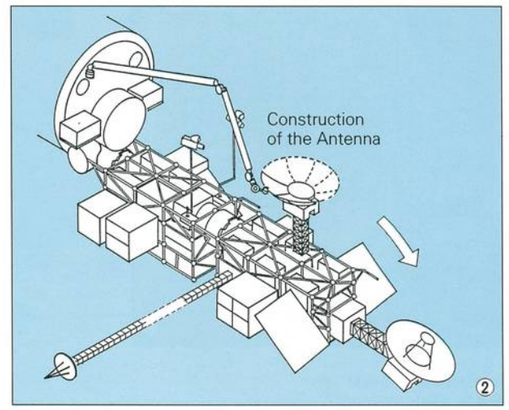
Recently the demand for measurements of biological materials with nondestructive methods has been increasing with the development of bioscience technology. Developments of novel radio techniques for accurate determination of living (in vivo) dielectric properties are under study. This information would be useful for diagnostics or controls in a biological system.

有人宇宙時代通信の研究

COMMUNICATIONS TECHNOLOGY IN MANNED SPACE ERA

In the 21st century, it is expected that human activity in space, for various purposes, will increase. In such an era, space communications technology will play an important role. New research, not just a simple extension of conventional space communications research, is needed because of the particular requirements of communications in manned space such as for long distance and 3-dimensional communications networks.

Currently, various research projects which are expected to lead to meeting the above future requirements are being carried out. Communications experiments on small vessels, aircraft, and land mobiles using the ETS-V satellite are being carried out and intersatellite communications experiments using the ETS-VI satellite, which will be launched in 1992, are in preparation. In the future, the research field will be expanded to include a communications system for a space colony. Such a system would provide internal communications in a colony and communications among colonies, earth, moon base and space ships traveling toward deep space.



① Advanced Satellite Communications Experiments Using ETS-VI

A program to develop advanced satellite communications systems incorporating S-band (2 GHz band), millimeter-wave, and optical communications payloads planned for the ETS-VI which will be launched in 1992. This program plans to establish fundamental technologies for intersatellite communications. Personal satellite communications experiments with the millimeter-wave payload are also planned.

② Experiments on Space Station

An experiment to be conducted is the construction of a large aperture antenna, using a robot arm, on a space station which will be developed by the U.S.A., Japan, and European countries. Experiments on large capacity data transmission in millimeter and optical wave ranges, and earth observation, such as rainfall observation by radar, will be conducted using the antenna.

③ Multibeam Antenna for Intersatellite Data Relay System

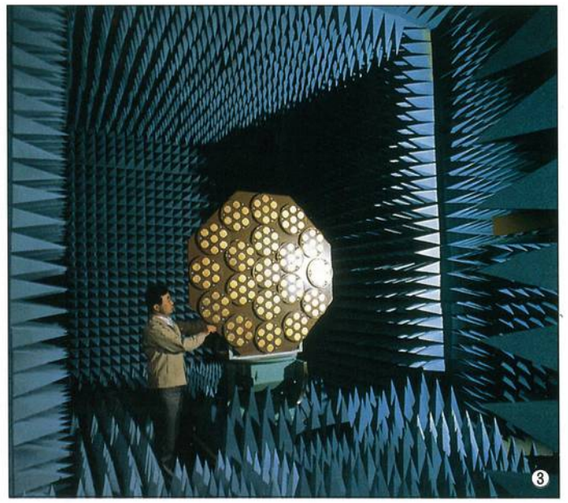
In the Intersatellite Data Relay System, a multibeam antenna is used for tracking multiple user satellites simultaneously. CRL developed a 19-element phased array antenna with steerable multibeams.

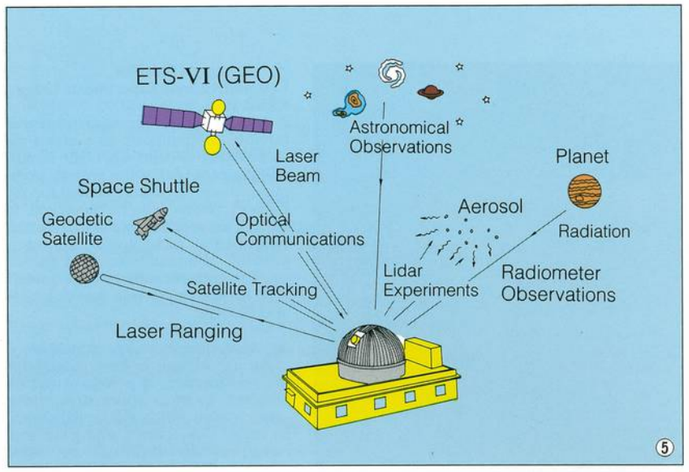
The figure shows the antenna under testing using the Near-Field Antenna Measurement System.

On the basis of the results, the mission payload for S-band intersatellite communications is to be loaded on the ETS-VI (Engineering Test Satellite- VI) which is to be launched in 1992, and data-relay experiments are scheduled to be conducted.

④ Compact Earth Terminal

The 20 GHz-band receive-only compact earth terminal with a 30 cm diameter antenna is used for an experimental data distribution system which delivers data such as news, stock information and weather.



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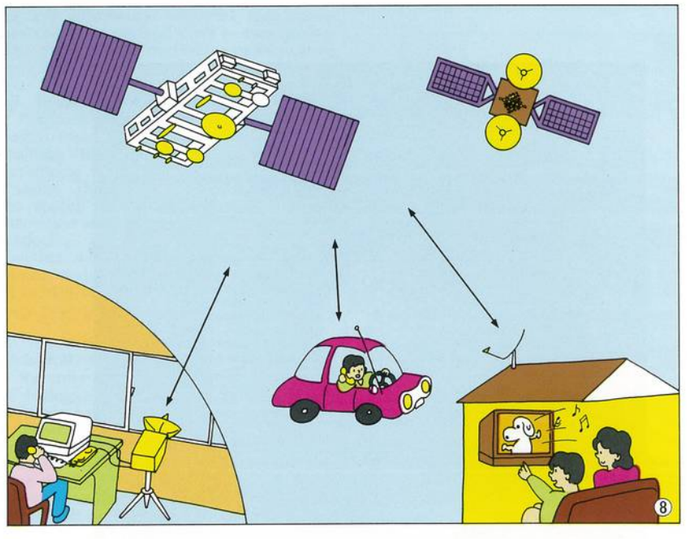


⑤ Observation Ojbects of the Telescope
⑥ 11 m dome and 1.5 m Telescope
⑦ Console for Telescope Operation

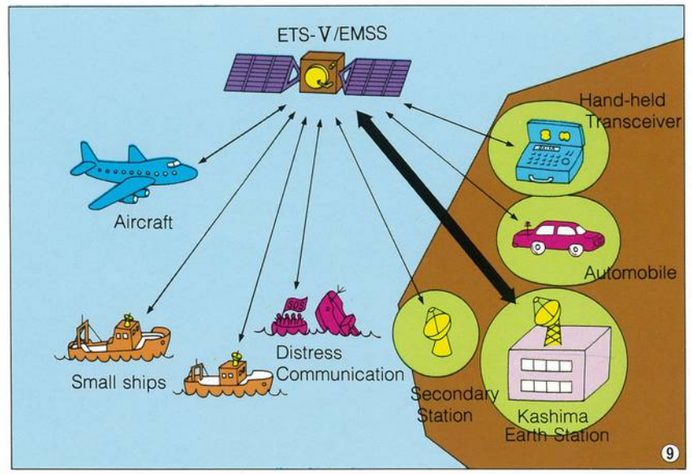
The Space Optical Communications Research Center is a new optical facility for conducting research into the following.

1. Precise satellite tracking and laser ranging
2. Space optical communications
3. Astronomy
4. Laser radar (Lidar)
5. Radiometer observations

A main system in this facility is a 1.5 m telescope with interchangeable Cassegrain, Vent-cassegrain, Nasmyth and Coude room located just below the 11 m dome, on which large instruments such as laser systems are installed. The telescope can track low altitude satellites easily and precisely.

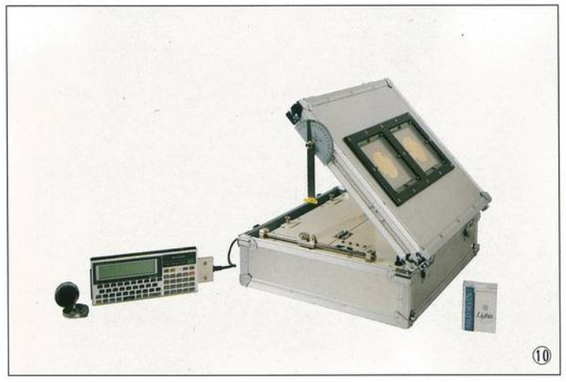
⑧ Advanced Space Communication Sytems

A millimeter-wave personal satellite communication system is being studied as a convenient use of space communications by the general public. A broadcast satellite system in the 22 GHz band is also being studied as a regional satellite broadcast service to provide many channels for each region in Japan.



⑨ Concept of Mobile Satellite Communications Experiments using ETS-V

An Experimental Mobile Satellite System (EMSS) with the ETS-V satellite as the space segment is being developed for the purpose of establishing basic technology for future integrated mobile satellite communications systems which offer maritime, aeronautical and land mobile services. The EMSS provides several kinds of channels; near toll quality digitized voice channels for small vessels and aircraft, moderate quality voice channels for automobiles, and low speed data channels for hand held terminals, etc.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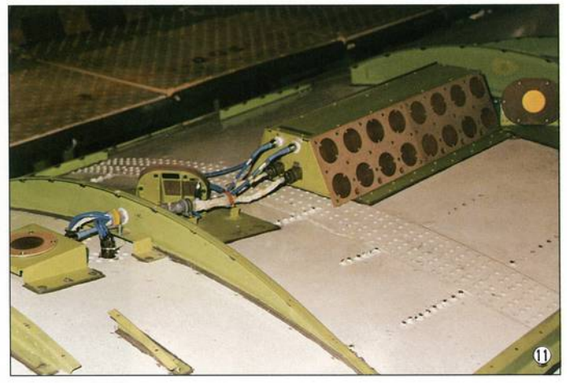
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⑩ Hand-Held Message Communicator

The hand-held message communicator is the smallest, lightest weight earth station of all the types of earth stations developed in the EMSS project. Resembling an attache case, a person can carry it anywhere. To contact another ground earth station, he need only point the antenna on the lid toward the satellite. This earth station can transmit and receive messages at very low speed (100 bps) through satellite links.

Research on even smaller compact units is still being conducted.

⑪ Antenna of Aircraft Earth Station

Adopted in the aircraft earth station is a newly developed phased array antenna, one which can track the satellite by electronic scanning. The antenna is installed inside a fairing on the top of the fuselage of a Boeing 747.

The phased array antenna was specially designed for installation in a Boeing 747 in order to overcome severe conditions such as space limitations, thermal extremes, and mechanical strength, and to satisfy safety requirements of the aircraft.

In-flight experiments are performed mainly on a transoceanic flight route between Tokyo and Anchorage.

⑫ Land Mobile Earth Station

Satellite communication is to be introduced for land mobiles as well as for ships and aircraft.

Several types of communication terminals for automobiles have been developed for use in communication experiments with ETS-V.

⑫: ACSSB communication terminal for automobile telephone.

電磁波物性・材料の研究

MATERIAL SCIENCE AND QUANTUM DEVICES

Recently, material physics has taken on more importance in the field of information and communication technology. The CRL has been carrying out several research projects and has developed various new technologies in this field through research on the interaction between electromagnetic waves and material.

Currently, we are emphasizing the following two fields: high-temperature super-conducting material, now being watched with keen interest, and its application for detection of millimeter and sub-millimeter electromagnetic waves; and generation and application of undeveloped electromagnetic-wave technologies including lasers. Moreover, the development of highly stable frequency standards (atomic clocks) using new laser techniques is also in progress.

These researches will be useful for establishing the fundamental and important technology which will be the key technology to realizing future electrical communication characterized by much higher speed and performance than that of today.


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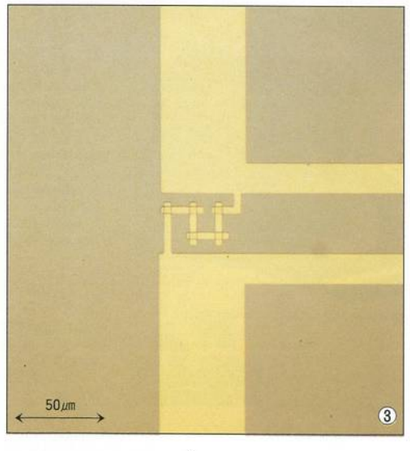
①② Facilities for Micro-Lithography
Research in the tera-hertz frequency region is likely to have a great impact on advanced telecommunications for the next age. Micro-lithography techniques are indispensable for active elements.



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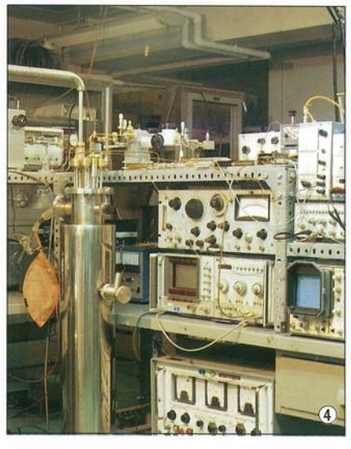
③ A Superconductive Device for Quasi-Optical Detection of Short-Millimeter and Submillimeter Waves
A device is under development for high sensitivity detectors and imaging device applications. It is composed of multielements made of niobium films and integrated on a single chip of silicon substrate. Each element is comprised of a series array of five Josephson junctions and a super-conducting half wavelength dipole antenna.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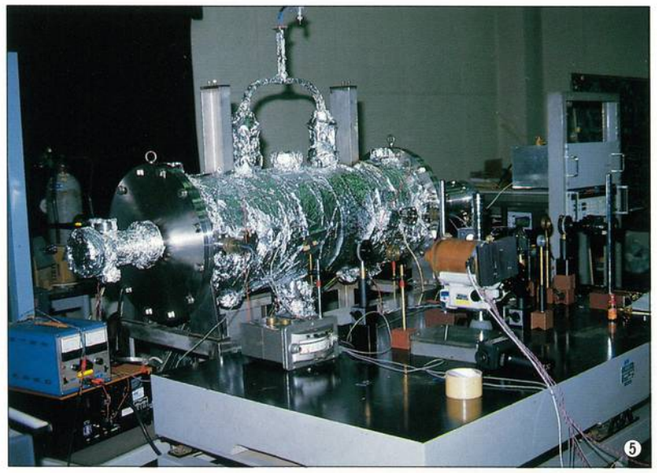
④ Superconductive Technology for Communications (Experimental setup for a Josephson mixer)
Superconductivity applications have been limited in some special cases because it is effective only at extremely low temperatures. The recent discovery of high-Tc-superconductivity has brought new possibilities for diverse applications in the near future. Basic study is in progress.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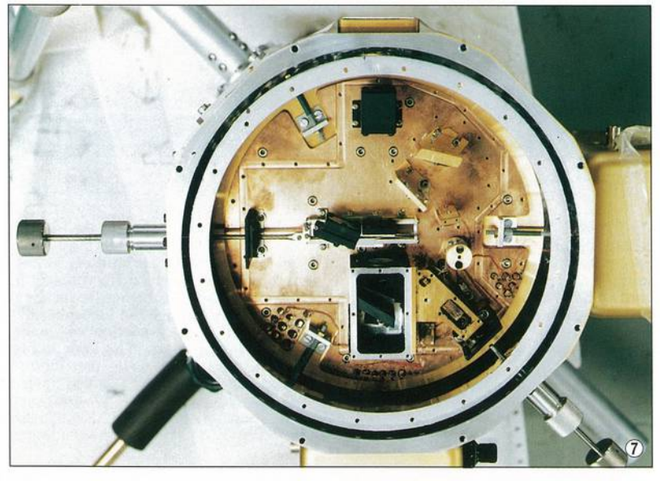
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⑤ Optically Pumped Frequency Standard
An optically pumped cesium beam frequency standard is being developed as a promising candidate for the future primary frequency standard.

⑥ Ion Storage Frequency Standard
In order to realize an ion storage frequency standard, basic research on trapping and laser cooling of ions is being carried out.

⑦ Study on Stressed Ge: Ga Far-Infrared Photoconductors
Sensitive stressed Ge: Ga photoconductors which have responses up to 200 microns have been developed as well as non-stressed Ge: Ga photoconductors covering 60–110 micron wavelengths. This detector technology should be of great advantage to many fields of far-infrared studies, plasma physics, and so on. (⑦ is a liquid He cooled apparatus used for performance tests of stressed Ge: Ga photoconductors.)

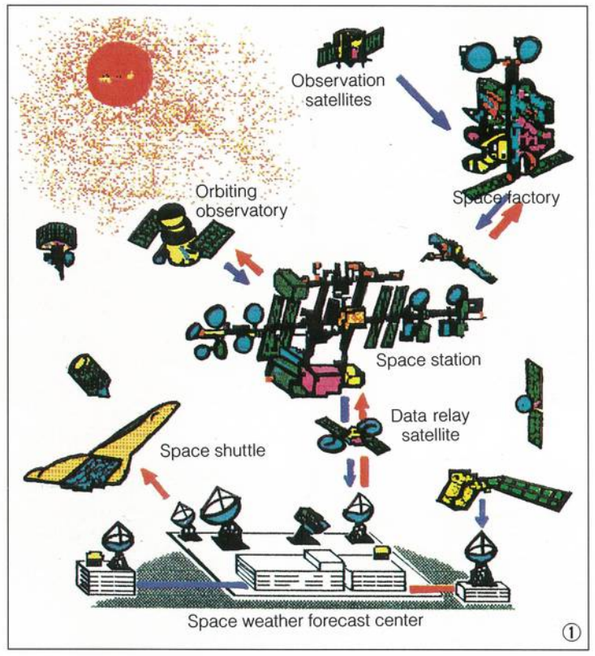
地球惑星系環境の研究

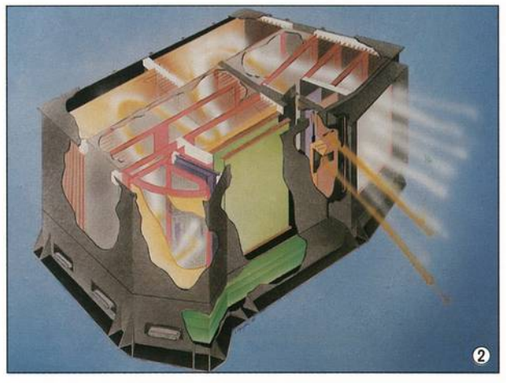
SPACE AND EARTH SYSTEM SCIENCE

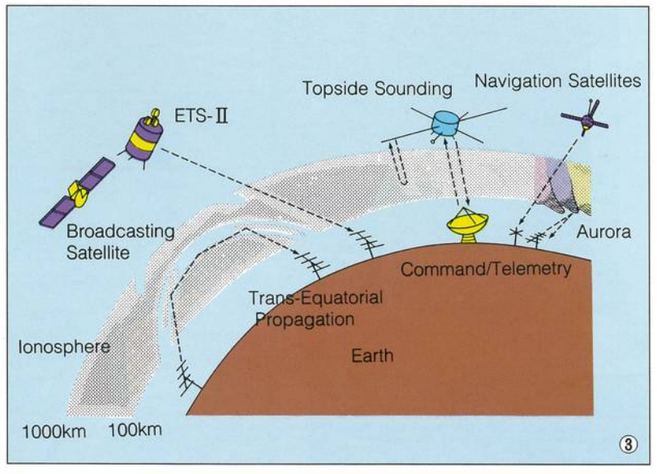
In the early 21st century, it is expected that humans will be active beyond imagination, not only on the earth but also extending to the moon and all of space. While looking outward, we also feel concern for the change of the earth's environment and the biosphere with the progress of human activities.

In order to deal with these problems, it is indispensable to understand the global mechanism and system of the earth through research on the physical phenomena of space and the effect which our primary source of energy, namely the sun, exercises on the earth.

Therefore, CRL is developing high-level remote sensing and ultra-precise measuring technology, a coordinated system for observation of the earth and space using those techniques, a space weather forecasting system for predicting changes of the space environment, and so on.







① **Space Weather Forecast**
Solar activity will continue for the next few days, please take precautions to prevent radiation injury, if you are going out in space.

We are looking ahead to the first part of the next century when regular space "weather" forecasts will be needed to warn people living in orbit of imminent radiation danger.

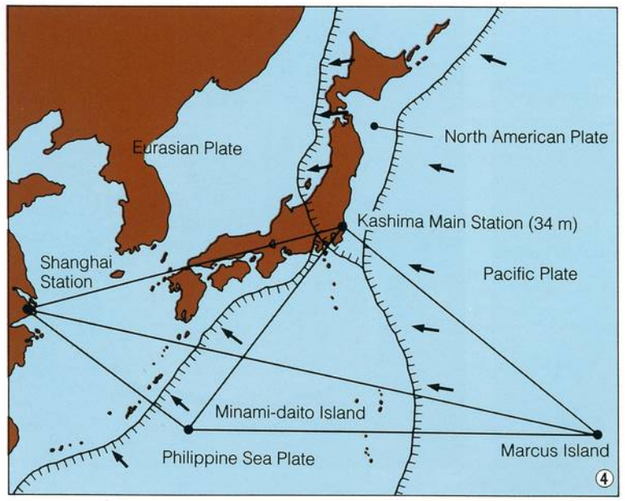
The plan is to undertake space weather forecasts by measuring dangerous changes in the space environment to ensure the protection of human health and the safe operation of space equipment.

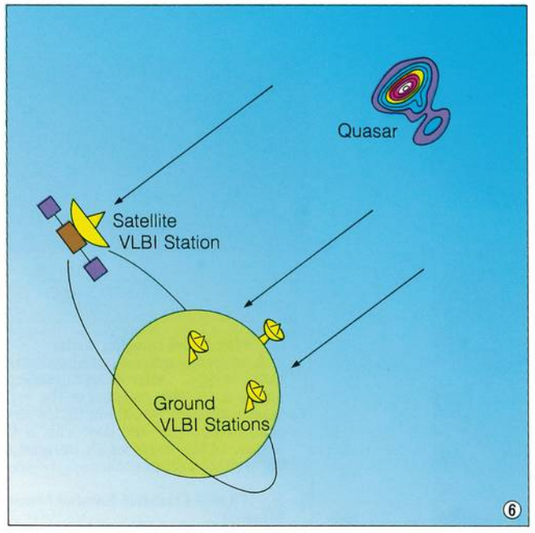
② **EXOS-D/SMS**

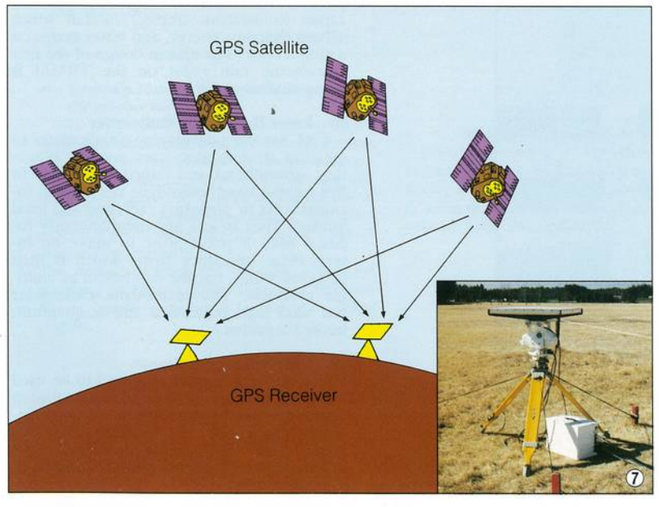
The aurora display is one of the most spectacular phenomena occurring in the solar-terrestrial environment. The EXOS-D satellite will be launched early in 1989 to explore auroral phenomena. One of nine instruments on board the satellite is a suprathermal ion energy-mass spectrometer (SMS) now under development by CRL and NRC of Canada.

③ **Satellite Observations of the Ionosphere**

Ionospheric effects on the propagation of satellite radio waves are studied. Ionospheric irregularities produce fluctuations in intensity and phases of higher frequency radio waves passing through the ionosphere, often resulting in the degradation of quality in space communications. The variation in the total electron content in the ionosphere affects accuracy in satellite-aided navigation systems, remote sensing, and time comparison. These effects are investigated by observations of satellites including ISIS 1&2, ETS-II, and NNSS.







④ **Western Pacific Radio Interferometer System**

Subduction of the Pacific and Philippine Sea plates under the Japanese Island is thought to be responsible for the occurrences of great earthquakes. This VLBI system is designed to monitor the movements of these plates from the main station at Kashima and from two remote island stations, Minami-Torishima (Marcus Island), and Minami-Daitojima.

⑤ **34 m Antenna**

A newly built 34 meter parabolic antenna at Kashima is used as the main VLBI station antenna of the Western Pacific Radio Interferometer. This antenna is also used for radio astronomical observations of various celestial radio sources such as pulsars.

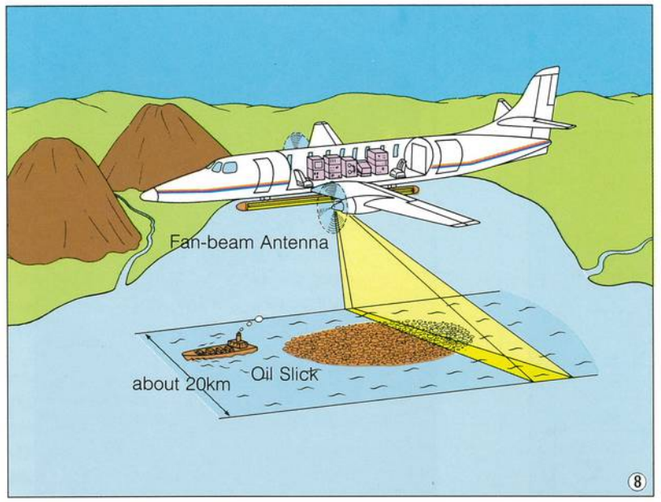
⑥ **Space VLBI Experiment**

The first Space VLBI experiment was successfully performed in July 1986. The satellite used in the experiment is NASA's TDRS. This success gave us the perspective of a giant radio telescope connecting a satellite with the earth.

⑦ **Precise Positioning Using GPS**

A GPS (Global Positioning System) receiving system is being developed in order to obtain cm accuracies for relative positions. The system is useful in geodesy, time comparison, and earthquake predictions. Precise orbit determination experiments are planned.

地球惑星系環境の研究
SPACE AND EARTH SYSTEM SCIENCE



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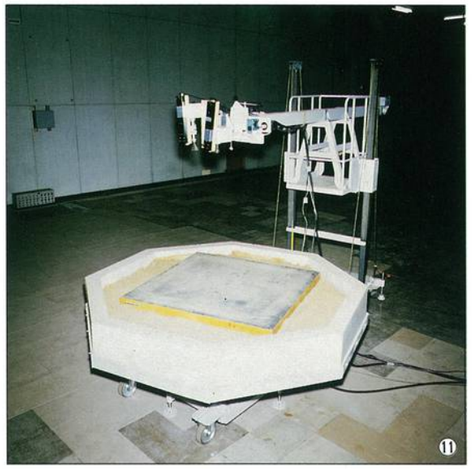
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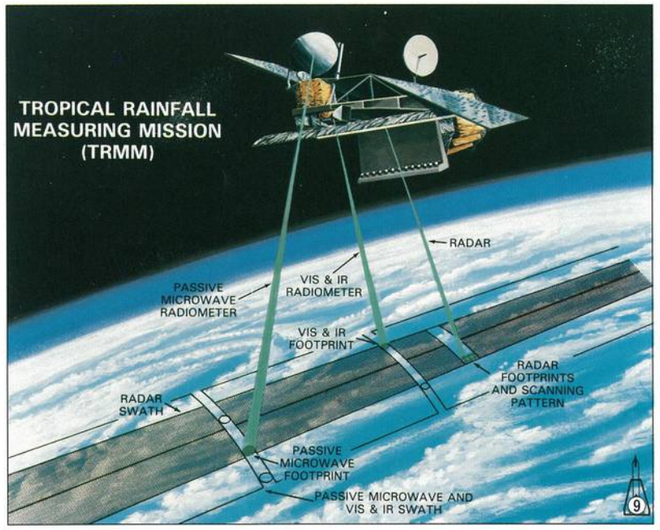

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⑧ **Microwave Imaging Radar**
A study on microwave imaging radar has been made. Microwave imaging radar makes it possible to observe the earth's surfaces with high resolution under all-weather conditions, night and day. This is the main feature of the radar which infrared and visible sensors cannot realize.

⑨ **TRMM (Tropical Rainfall Measuring Mission)**
The TRMM project is being studied in a joint venture between the U.S.A. and Japan to measure tropical rainfall which affects climates, energy, and water cycles on a global scale. The system design of the first spaceborne rain radar on the TRMM is being studied at CRL.

⑩ **Laser Heterodyne Radiometer**
CRL has been developing a radiometer to measure stratospheric trace species, planetary atmospheres and interstellar gases. In this passive laser heterodyne radiometer, incident solar or planetary radiation and local infrared laser beams are simultaneously focused onto a photomixer to make an intermediate frequency signal which is then detected with a narrow bandwidth at multiple channels. The heterodyne radiometer has ultra-high resolution and a quantum-limited sensitivity.

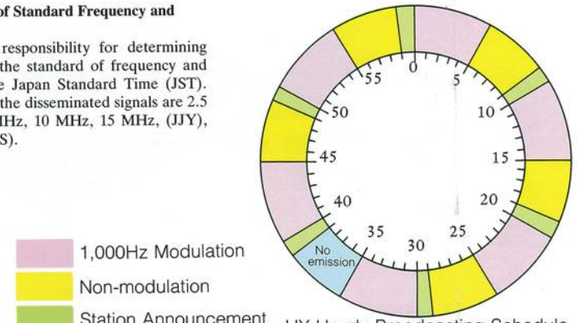
⑪ **Millimeter Wave Sensor**
Millimeter waver are expected to be used for short distance sensors such as collision prevention sensors for cars, and various industrial uses. On this subject, CRL has started basic experiments to measure the millimeter wave scattering characteristics of various targets.

REGULAR SERVICES

◀ **Type Approval Test and Calibration for Radio Equipments**
Radio equipments which are indispensable for securing the safety of human life and are related to the efficient utilization of radio spectrum are legally obligated or recommended to obtain the type approval. The performance tests and the calibration service of equipments for measuring and monitoring are offered upon request.

Routine Ionosphere Sounding ▶
In order to obtain the distribution of electron density and the information necessary for the ionospheric propagation, the routine soundings are conducted every 15 minutes at Wakkanai, Akita, Kokubunji/Tokyo, Yamagawa and Okinawa stations as well as Syowa station in Antarctica.

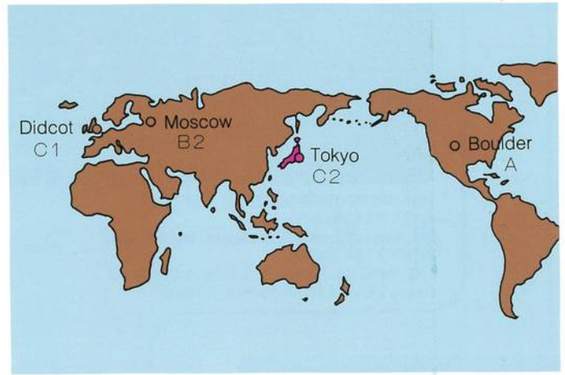
◀ **Dissemination of Standard Frequency and Time Signals**
CRL takes the responsibility for determining and disseminating the standard of frequency and time as well as the Japan Standard Time (JST). The frequencies of the disseminated signals are 2.5 MHz, 5 MHz, 8 MHz, 10 MHz, 15 MHz, (JJY), and 40 kHz (JG2AS).



JJY Hourly Broadcasting Schedule

TELEPHONE SERVICE STATION	TELEPHONE NUMBER
KOKUBUNJI HEADQUARTERS	0423-21-4949
HIRAISO SOLAR TERRESTRIAL RESEARCH CENTER	0292-65-7575
WAKKANAI RADIO WAVE OBSERVATORY	0162-22-4949
AKITA RADIO WAVE OBSERVATORY	0188-31-1919
YAMAGAWA RADIO WAVE OBSERVATORY	09933-4-1919
OKINAWA RADIO WAVE OBSERVATORY	09889-5-4949
OSAKA	06-949-4949

▲ **Telephone Message Service for Radio Disturbance Prediction**
CRL offers the telephone message service for radio disturbance prediction. The message consists of not only the prediction of short wave propagation but also the summary of current solar and geomagnetic activities, a quick announcement of information on anomalous events in the solar-terrestrial environment, and the sunspot numbers observed and predicted.
The message is composed by using a personal computer at Hiraiso Solar Terrestrial Research Center. Anybody can get it by dialing the listed stations.



World Data Center C2 for Ionosphere ▲
Being designated as a world data center, CRL keeps the ionospheric data sent from observatories mainly in Asian and Oceania regions, and regularly exchanges the data with other centers. Such data are open to the public.

World Days Service and URSIGRAM
CRL, as the Western Pacific Regional Warning Center of the URSIGRAM, issues the radio propagation warning and broadcasts the URSIGRAM messages including satellites launch information everyday at 10.415 MHz and 15.950 MHz.

Publications

1. CRL News (in Japanese) — Monthly
2. CRL Annual Bulletin (in Japanese) — Annually
3. Review of the Communications Research Laboratory (in Japanese) — Quarterly
4. Journal of the Communications Research Laboratory — Thrice a year
5. Ionospheric Data in Japan — Monthly
6. Standard Frequency and Time Service Bulletin — Monthly
7. Catalogue of Data in World Data Center C2 for Ionosphere — Annually
8. Ionosphric Data at Syowa Station (Antarctica) — Semi-annually