EARTH OBSERVATION SATELLITE PROJECTS IN JAPAN

Shunji Murai  
Institute of Industrial Science, University of Tokyo

Toshibumi Sakata  
Research and Information Center, Tokai University  
Japan

Commission I

ABSTRACT
The paper deals with the basic policies of earth observation system and earth observation satellite projects in Japan. Two satellites, Marine Observation Satellite (MOS-1) and Earth Resources Satellite (ERS-1) have been approved to launch in 1986 and 1990 respectively.

In addition, the long-term vision for earth observation satellites have been proposed in July, 1983 by the Space Development Commission.

Information in this paper were obtained from governmental reports or committee reports, as the authors have been serving for long years as the members of committees or working groups for making drafts or recommendations to the Government in the field of remote sensing.

INTRODUCTION
Since the launch of LANDSAT-1 was announced by U.S.A., the Space and Technology Agency (STA), the Government of Japan started the Committee on Interpretation Techniques for Earth Resources Satellite Data in 1970. This Committee was responsible for investigations on ERTS imagery since ERTS-1 was launched in 1972.


According to the Space Development Plan approved in 1977, LANDSAT Receiving Station was constructed in 1979. In 1979, the development of MOS-1 was approved as one of Marine Observation Satellite Series.

Since 1977, Inter-ministerial Meeting on Remote Sensing has played a role of coordination for comprehensive promotion in the field of remote sensing.

In July, 1983, the Space Development Commission submitted a report titled "Long-term Vision on Space Development in Japan " which was revised from the former report in 1977. In this report, not only remote sensing but also all other space technologies were proposed in the range up to the end of 1990's, that is the end of twenty centuries.

Functions and requirements of next generation's satellites or sensors are now studied under the Committee on Next Generation Earth Observation Satellites which is established in Remote Sensing Technology Center. The authors are serving to the Committee as remote sensing experts.
BASIC POLICIES OF SPACE DEVELOPMENT

The following three policies have been fundamental for space development in Japan.

1) To develop own technologies including rocket, three axis attitude control system, sensors, data processing devices, software and so on,

2) To promote operational utilization by integrating cooperation between users and developers,

and

3) To promote international cooperation to share the roles on space development and data utilization.

ROLES OF EARTH OBSERVATION

The following four roles are expected for Japanese earth observation satellites.

1) Data acquisition of surrounding sea area for fishery and oceanographic monitoring as well as domestic land area for land use, vegetation and natural disaster prevention,

2) Global information collection including mineral, energy, food etc.,

3) International cooperation to provide developing countries with satellite data, and to exchange or share information with advanced countries, and

4) Promotion of advanced technologies including semi-conductive sensors, data processing system and so on.

USERS OF SATELLITE DATA IN JAPAN

Operational utilization of satellite remote sensing data is limited to meteorology while utilization of LANDSAT data is becoming nearly operational in the specific fields. However, most of users request the improvement of resolution, frequency of cloud free images and accuracy of classification or analysis.

Users of satellite remote sensing data in Japan are classified into the following five levels.

Level 1: Established users of operational utilization
   a. Resources Explorer: reconnaissance survey of mineral resources
   b. Agricultural Development Organizations: selection of suitable land
   c. Environmental Monitoring Agencies: monitoring of environment
   d. Meteorological Agency: meteorological observation and forecast

Level 2: Assured users of operational utilization
   a. Coast Guard Agency: monitoring sea ice
   b. Fishery Information Center: sea temperature mapping
   c. Land Information Agency: renewal of land information
   d. Geographic Survey Institute: small scale image map production
Level 3: Expected users of operational utilization

a. Fishery Agency: monitoring of inland sea environment
b. Disaster Prevention Center: monitoring of natural disaster
c. Environmental Protection Agency: measurement of pollutants
d. Forestry Agency: monitoring of forest change
e. Farmers Union and Trade Companies: crop harvest forecast

Level 4: Users of semi-operational utilization

a. Coast Guard Agency: current mapping
b. Environmental Protection Agency: monitoring of oil spill
c. Meteorological Agency: improvement of weather forecast
d. Ministry of Public Affairs: damage mapping by natural disasters
e. Ministry of Agriculture, Forestry and Fishery: crop identification
f. Japan International Cooperation Agency: resources management
g. Ministry of International Trade and Industry: industrial pollution control
h. Local Governments: regional survey and planning

Level 5: Users for academic purposes

a. Solid Earth Physics: research on geoid and earth movement
b. Oceanography: research on ocean dynamics
c. Meteorology: research on heat exchange, polar ice, desertification, atmosphere etc.

LONG TERM EARTH OBSERVATION SATELLITE PROJECTS IN JAPAN

Three earth observation satellite series are proposed as follows:
1) Marine Observation Satellite (MOS) Series
2) Earth Resources Satellite (ERS) Series
3) Geostationary Earth Observation Satellite (GEOS) Series

Though only MOS-1 (1986) and ERS-1 (1990) are approved by the Government of Japan at the present (1984), the long term plan up to the latter half of 1990's is now being discussed in the Committee on "Next Generation Earth Observation Satellites".

The term is divided into three terms as follows:

1) Latter half of 1980's

This term is defined as experimental stage for launching satellites, testing sensors and distributing data to various users. MOS-1 and ERS-1 will be launched in 1986 and 1990 respectively.

2) Former half of 1990's

This term is defined as engineering test stage. MOS-2 and MOS-3 will be launched. ERS-2a and ERS-2b as well as GEOS-1 will be launched in this term.

3) Latter half of 1990's

This term is defined as operational stage. Therefore multiple satellites will be launched to increase frequency of data acquisition. MOS-4a and 4b, MOS-5a and 5b, as well as ERS-3a and 3b and GEOS-2 will be launched in this term.

Earth Observation Technology Satellite (EOTS) for testing high resolution sensors and for developing on-board processing system will be launched in the end of 1990's.
Figure 1 shows the relation between earth observation satellite series and technology advancement.

Table 1, Table 2 and Table 3 summarize the major characteristics of MOS, ERS and GEOS series respectively.

MARINE OBSERVATION SATELLITE (MOS) -1

The National Space Development Agency (NASDA) will launch MOS-1 in 1986 under the direction of the Science and Technology Agency (STA), the Government of Japan.

Three sensors will be borne in MOS-1 as described below.

1) MESSR (Multispectral Electronic Self Scanning Radiometer)
2) VTIR (Visible and Thermal Infrared Radiometer)
3) MSR (Microwave Scanning Radiometer)

These sensors are now in the stage of flight model after completing Bread Board Model (BBM), Engineering Model (EM) and Proto-Flight Model (PFM).

The performance tests for these sensors will be done by using aircraft in the end of 1984. NASDA has called for investigators to participate in the performance tests for these sensors by the end of February, 1984.
<table>
<thead>
<tr>
<th>Year</th>
<th>Satellite</th>
<th>Purposes</th>
<th>Applications</th>
<th>Orbit</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>MOS-1</td>
<td>* Land cover</td>
<td>* Land survey</td>
<td>* Sun synchronous</td>
<td>* MESSR: 4 bands, 50 M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Turbidity</td>
<td>* Fishery</td>
<td>* 900 KM</td>
<td>* VTIR: 4 bands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea temperature</td>
<td>* Environment</td>
<td>* 18 days</td>
<td>* MSR: 2 channels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Vapor</td>
<td>* Meteorology</td>
<td>* 750 KG</td>
<td>* DCS</td>
</tr>
<tr>
<td>Former Half of 1990's</td>
<td>MOS-2</td>
<td>* Sea temperature</td>
<td>* Fishery</td>
<td>* Sun synchronous</td>
<td>* Altimeter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Vapor</td>
<td>* Disaster prevention</td>
<td>* 900 KM</td>
<td>* VTIR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Cloud</td>
<td>* Sea status monitoring</td>
<td>* 6 days/2 orbits</td>
<td>* MSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea topography</td>
<td>* Meteorology</td>
<td>* 900 KG</td>
<td>* DCS</td>
</tr>
<tr>
<td></td>
<td>MOS-3</td>
<td>* Sea topography</td>
<td>* Safety control</td>
<td>* 800 KM</td>
<td>* Data recorder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea wind</td>
<td>* Disaster prevention</td>
<td>* 6 days/2 orbits</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Chlorophyl</td>
<td>* Meteorology</td>
<td>* 1.4 TON</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea temperature</td>
<td>* Fishery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latter Half of 1990's</td>
<td>MOS-4a,b</td>
<td>* Ships</td>
<td>* Safety control</td>
<td>* 800 KM</td>
<td>* Altimeter</td>
</tr>
<tr>
<td></td>
<td>MOS-5a,b</td>
<td>* Sea wind</td>
<td>* Navigation</td>
<td>* 4 days/2 orbits</td>
<td>* Scatterometer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea topography</td>
<td>* Disaster prevention</td>
<td>* 2.2 TON</td>
<td>* MSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Chlorophyl</td>
<td>* Fishery</td>
<td></td>
<td>* CZCS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sea temperature</td>
<td>* Meteorology</td>
<td></td>
<td>* DCS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Salinity</td>
<td></td>
<td></td>
<td>* Data recorder</td>
</tr>
</tbody>
</table>
### Table 2  Earth Resources Satellite Series

<table>
<thead>
<tr>
<th>Year</th>
<th>Satellite</th>
<th>Purposes</th>
<th>Applications</th>
<th>Orbit</th>
<th>Sensors</th>
</tr>
</thead>
</table>
| 1990            | ERS-1     | * Geology  
* Land use  
* Vegetation  
* Chlorophyl | * Resources inventory  
* Land survey  
* Fishery  
* Environment  
* Disaster prevention | * Sun synchronous  
* 570 KM  
* 42 days  
* 1.4 TON | * SAR: L band, 25M  
* VNIR, 4 bands, 25M  
* Data recorder |
| Former Half of 90's | ERS-2     | * Geology  
* Land use  
* Vegetation | * Resources inventory  
* Agriculture  
* Land survey | * Sun synchronous  
* 900 KM  
* 48 days/2 orbits | * SAR: L band, 25M  
* VNIR, 6 bands, 15M  
* Data Relay System |
| Latter Half of 90's | ERS-3     | * Geology  
* Land use  
* Vegetation  
* Chlorophyl  
* Temperature | * Resources inventory  
* Agriculture  
* Land survey  
* Environment | * Sun synchronous  
* 700 KM  
* 18 days/2 orbits  
* 2.0 TON | * SAR: L band, 25M  
* VNIR: visible -3 bands  
(15 M)  
NIR-3 bands  
(100 M)  
TIR-3 bands  
* VNIR, 4 bands, 50M  
* Data Relay System |

### Table 3  Geostationary Earth Observation Satellite Series

<table>
<thead>
<tr>
<th>Year</th>
<th>Satellite</th>
<th>Purposes</th>
<th>Applications</th>
<th>Orbit</th>
<th>Sensors</th>
</tr>
</thead>
</table>
| Former Half of 90's | GEOS-1    | * Chlorophyl  
* Cloud  
* Sea temperature  
* Red tide  
* Sea color  
* Atmosphere | * Oceanography  
* Meteorology  
* Disaster prevention  
* Environment  
* Fishery | * Geostationary  
* 36,000 KM  
* Real time  
* 1.0 TON | * VNIR, 4 bands, 1 KM  
* TIR, 4 bands, 5 KM  
* MSR: 18, 24, 31 GHz  
* DCS |
| Latter Half of 90's | GEOS-2    | * Chlorophyl  
* Cloud  
* Sea temperature  
* Current | * Oceanography  
* Disaster prevention  
* Fishery  
* Environment | * Geostationary  
* 36,000 KM  
* Real time  
* 2.0 TON | * VIR; V/NIR: 4 bands, 1KM  
TIR: 4 bands, 3KM  
* SAR, X band, 25 M  
* MSR: 5,10,20,30 GHz  
* DCS  
* Data Relay System |
1) MESSR (Muti-Spectral Electronic Self Scanning Radiometer)

MESSR is a pushbroom scanner with Charge Coupled Device (CCD) image sensor. The major characteristics are summarized in Table 4.

Figure 2 shows three folded non-linear gain curves which will be adopted to two visible bands in order to permit high gain for low reflection range, for example, water body and vegetation.

![Non Linear Gain Curves for MESSR](image)

**Figure 2** Non Linear Gain Curves for MESSR

2) VTIR (Visible and Thermal Infrared Radiometer)

VTIR is a mechanical scanner for marine observation in the wide area with rather low resolutionIFOV. The major characteristics are shown in Table 5.

3) MSR (Microwave Scanning Radiometer)

MSR is not an imaging sensor but a sensor for atmosphere correction by detecting liquid cloud and water vapor.

MSR has two channels of 23.8 GHz for liquid cloud and 31.4 GHz for water vapor. IFOV of MSR is 32 KM for 23.8 GHz and 23 KM for 31.4 GHz respectively for the swath width of 320 KM.

Figure 3 shows the data format for image data taken by MESSR and VTIR.

![Data Format for MESSR and VTIR Image Data](image)
### Table 4. Major Characteristics of MESSR for MOS-1

| Spectral bands   | 1. 0.51 - 0.59 um  
|                 | 2. 0.61 - 0.69 um  
|                 | 3. 0.72 - 0.80 um  
|                 | 4. 0.80 - 1.10 um  
| Swath width      | 2x 100 KM          
| Detector         | 2x 2048 CCD/ band  
|IFOV             | 55 urad. or 50 M on the ground  
| Quantizing bits  | 6 bits             
| Photo sensitivity| ± 30 %             
| Data rate        | 8 Mb/s             
| Signal to noise ratio | 38 dB : designed  
|                  | 37 dB : observed   
| Scanning period  | 7.6 msec           
| Output frequency | 8 GHz (X band)     
| Output power     | 4 W                
| A/D Conversion   | non linear for visible bands (1&2)  
|                  | linear for IR bands (3&4) ( see Figure 2 )  

### Table 5. Major Characteristics of VTIR for MOS-1

| Spectral bands   | 1. 0.5 - 0.7 um  
|                 | 2. 6.0 - 7.0 um  
|                 | 3. 10.5 - 11.5 um  
|                 | 4. 11.5 - 12.5 um  
| Swath width      | 1500 KM           
| IFOV            | 900 M for visible band  
|                 | 2700 M for thermal IR bands  
| Quantizing bits  | 6 bits             
| Data rate        | 0.8 Mb/s           

EARTH RESOURCES SATELLITE (ERS) -1

ERS-1 has been approved by the Government of Japan to launch in 1990. Though the final design of sensors and other parameters are not yet finalized, the preliminary design was proposed as shown in Table 6.

Two sensors of SAR (Synthetic Aperture Radar) and VNIR (Visible and Near Infrared Radiometer with 25 m resolution will be borne in ERS-1.

<table>
<thead>
<tr>
<th>Table 6 Major Characteristics of ERS-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launching year</td>
</tr>
<tr>
<td>Altitude</td>
</tr>
<tr>
<td>Orbit</td>
</tr>
<tr>
<td>Attitude control accuracy</td>
</tr>
<tr>
<td>Sensors</td>
</tr>
<tr>
<td>1) SAR</td>
</tr>
<tr>
<td>Swath width</td>
</tr>
<tr>
<td>Resolution</td>
</tr>
<tr>
<td>Data rate</td>
</tr>
<tr>
<td>Band</td>
</tr>
<tr>
<td>Off nadir angle</td>
</tr>
<tr>
<td>Polarization</td>
</tr>
<tr>
<td>2) VNIR</td>
</tr>
<tr>
<td>Swath width</td>
</tr>
<tr>
<td>Resolution</td>
</tr>
<tr>
<td>Data rate</td>
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<tr>
<td>Bands</td>
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<tr>
<td></td>
</tr>
<tr>
<td>FOV</td>
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<tr>
<td>CCD</td>
</tr>
</tbody>
</table>

REFERENCES

1) Space Development Division, Space and Technology Agency; "Utilization Vision on Earth Observation Satellites"; Oct., 1982

2) Space Development Commission; "Long Term Vision on Space Development in Japan"; July, 1983

3) R.Kuwano et al.; "Multispectral Electronic Self Scanning Radiometer for MOS-1"; NEC Research & Development, No.64, Jan., 1982

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