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MISSION REQUIREMENTS FOR
A MANNED EARTH OBSERVATORY

TASK 2 – REFERENCE MISSION DEFINITION
AND ANALYSIS

Contract No. NAS8-28013

31 May 1973

VOLUME II

(NASA-CR-174346) MISSION REQUIREMENTS FOR
A MANNED EARTH OBSERVATORY. TASK 2:
REFERENCE MISSION DEFINITION AND ANALYSIS,
VOLUME 2 (TRW Systems Group) 269 p HC
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Prepared for
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

Prepared by
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FOREWORD

The documentation on the "Mission Requirements for a Manned Earth Observatory" study, performed for the NASA Marshall Space Flight Center, Huntsville, Alabama, under Contract NAS8-28013 resulted in a four volume report. These volumes are:

Volume I  Task 1 — Experiment Selection, Definition and Documentation, Report No. 21324-6001-RU-00, 12 April 1973.


On this study, TRW Systems was contractually assisted by Earth Satellite Corporation, Washington, D. C., and by Model Development Laboratory, Alhambra, California.

The contents of these reports pertain to the mission requirements and conceptual design of Shuttle sortie payloads that could be flown in the 1980s. In developing this information, projections of 1980 sensor technology and user data requirements were used to formulate "typical" basic criteria pertaining to experiments, sensor complements, and reference missions. These "typical" criteria were then analyzed in depth to develop conceptual payloads that are within the capabilities of the Shuttle/Sortie Lab mission capabilities. These payloads, therefore, should not be considered to be potential candidates for Shuttle missions, but only as typical conceptual payloads.

Future studies will be directed more specifically to the development of requirement and conceptual designs for potential Shuttle payloads, such as a Manned Earth Observatory that would be used as a sensor development Laboratory and to accommodate unique data acquisition requirements that would be supportive and complementary to the earth observations automated satellite programs.

Additional information pertaining to this document may be obtained from the NASA Contracting Officer's Representative, Mr. Donald K. Weidner, Marshall Space Flight Center, Huntsville, Alabama 35812.
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- Experiments
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- Power
1.0 INTRODUCTION

In Task 1, the 60 candidate experiments originally compiled by the study disciplinarians were subjected to three filters in order to permit the selection and justification of those experiments which could best be performed on the Shuttle (see Figure 1-1). The three filters were:

- Experiment characteristics
- Importance
- Technology

The 54 experiments which successfully passed these filters were documented according to one of three formats which reflected the experiment's applicability to early Shuttle Sortie reference missions, and particularly, their applicability to the derivation of mission requirements (see Volume 1). The class of experiments within each documentation level were:

- Level 1 - potential reference mission experiments.
- Level 2 - experiments that were considered applicable to early Shuttle Sortie missions but they were of lower overall importance than Level 1 experiments and all the measurement/observation requirements had not yet been determined.
- Level 3 - experiments of lower overall importance than those of Level 1 or 2 and/or many important elements remain to be defined.

Thirty Level 1 experiments were documented. These were used to develop reference missions.

In preparation for experiment scheduling and mission time-lining, the Level 1 experiment sensors were further defined and specified in terms of their performance/physical characteristics and platform considerations.

The guidelines used in synthesizing reference missions were specific, in that they addressed the 30 Level 1 experiments, and general, in that consideration was given to capabilities of the Shuttle. A total of nine reference missions were selected as potential MEO missions and prioritized in terms of their relevancy for user needs of the late 1970s and early 1980s.

These nine prioritized reference missions were divided into three groups (see Figure 1-1). The first mission was carried through a complete computer mission analysis which included orbital optimization, experiment scheduling and resource summaries.
Figure 1-1. Inputs to Mission Analysis
The second group of missions was carried through the orbital optimization to obtain a typical range of orbit requirements for earth observation Shuttle missions. The third group consisted of the reference missions of lower overall importance and were not carried through a computer analysis.

The first phase of the computer mission analysis used two computer programs (OTO and PACER) to provide orbital optimization. If the observation requirements for a mission were expressed in terms of frequency of coverage, OTO was used. If the objective was to cover as much of the target areas as possible, and the frequency of coverage was unimportant, then PACER was used. For the four reference missions analyzed, OTO was required for orbital optimization.

Once the optimal orbit was established, three additional computer programs were employed to evaluate the selected orbit in detail in preparation for experiment scheduling. This evaluation considered:

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<td>Illumination conditions</td>
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<td>CARTOG</td>
<td>Additional targets along the subsatellite trace</td>
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<tr>
<td>RISET</td>
<td>Data station acquisition and loss times</td>
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</tbody>
</table>

After evaluating the first priority reference mission the orbit remained unchanged and no additional targets were added. OTO was then rerun to generate an ephemeris tape.

The experiment scheduling program, AESOP, required the following inputs:

- Sensor data bank
- Mission/experiment priorities
- Ephemeris tape

These inputs were compiled and AESOP was run for the first priority reference mission.

The output of AESOP consisted of:

- Experiment timelines
- Sensor timelines
- Data requirements (digital and film)
- Power requirements.
These were then analyzed in terms of sensor/experiment/mission commonality, role of man and data handling and management.

In addition to the analysis discussed above, the pollution mission was also evaluated in terms of its on-call capability for disaster assessment and its contribution to a multistage sampling program.

The 29-sensor pollution reference mission that was carried through the complete computer analysis is a complex and sophisticated mission which not only taxes the Shuttle Sortie Lab capabilities, but is rather expensive. To reduce the cost of this, as well as other missions, a low-cost mission definition rationale was developed. The effect of applying such a rationale to the pollution mission was then demonstrated.

2.0 MISSION SELECTION AND PRIORITIZATION

2.1 SELECTION CRITERIA

References missions or assemblages of experiments may emphasize:

a) Phenomena — Experiments emphasizing the acquisition of data dealing with air pollution, water pollution, eutrophication, floating debris, etc., would constitute a large, important area of investigation. So, too, would experiments addressing the inventorying and monitoring of ice (sea, pack, etc.), snow (pack, melt, etc.), ice dams, and state of the ground.

b) Geographical Areas — Many experiments which are both multidisciplinary and multi-phenomenon oriented emphasize particular areas, such as bays, coastlines, and urban areas.

c) Disciplines — Individual disciplines (e.g., agriculture, geology, meteorology, etc.) would provide the experiments that receive the greatest emphasis in a reference mission experiment assembly. There are also natural groupings of disciplines that relate to each other by virtue of the proximity of their targets and/or by virtue of the close interactive relationship that the disciplines bear to each other, as in meteorology and oceanography.

d) Time of Year — Many experiments have observables with specific temporal requirements. (e.g., early spring, winter solstice, etc.).
Choosing one of these categories as a central theme forms a selection foundation upon which a group of related experiments can be compiled.

In order to drive out mission requirements, accommodate a large section of the user community and still create a feasible reference mission, several additional guidelines were used:

- The mission should contain a reasonable mix of applications, research and operational experiments to accommodate as many users as possible.
- A sufficient number of experiments and sensors should be selected to utilize the experiment crew.
- All 30 Level 1 experiments should be used in at least one reference mission and each mission should have new experiments. By changing the experiment composition of missions, various interactions can be observed in terms of mission requirements.
- The mission should have a capability for on-call disaster warning/monitoring/assessment to monitor important targets of opportunity.
- The mission should supplement and complement automated programs.

2.2 MISSION SELECTION

Applying the selection criteria to the group of Level 1 experiments resulted in nine reference missions as shown in Table 2-1. Missions consisting of from 7-13 experiments were formed around each emphasis category. The missions were prioritized in terms of their relevancy to the user needs of the late 1970s and early 1980s so that the highest priority missions could be considered in the computer mission analysis. The assignment of priorities to the first four reference missions was in itself somewhat arbitrary, in that each mission had a high relevancy to the user needs of the late 1970s and early 1980s.

By the seventh priority mission all the Level 1 experiments had been assigned to at least one reference mission (see Figure 2-1). The first four priority missions utilize approximately 80 percent of the Level 1 experiments.
<table>
<thead>
<tr>
<th>Level 1 Experiments</th>
<th>Emphasis Categories</th>
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</thead>
<tbody>
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<td>Oceanography/Meteorology</td>
<td>Priority 3</td>
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<tr>
<td>Pollution</td>
<td>Priority 1</td>
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<tr>
<td>Environmental Impact</td>
<td>Priority 2</td>
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<tr>
<td>Winter</td>
<td>Priority 7</td>
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<td>Spring</td>
<td>Priority 4</td>
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<td>Summer</td>
<td>Priority 5</td>
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<td>Autumn</td>
<td>Priority 8</td>
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<td>Low Latitude</td>
<td>Priority 6</td>
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<tr>
<td>High Latitude</td>
<td>Priority 9</td>
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<tr>
<td>Geographical Area</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1: The Distribution of Level 1 Experiments in Nine Typical Reference Missions
Figure 2-1. Distribution of Level 1 Experiments Among the Prioritized Reference Missions
3.0 MISSION DEFINITION

3.1 INSTRUMENTATION

In Task 1, 54 applications and research experiments addressing a wide cross-section of problems in the earth observations disciplines were identified as potential candidates for early Shuttle Sortie missions. These were documented according to one of three formats. The choice of format documentation reflected each experiment's applicability as a candidate for MEO missions that would be conducted during the first several years of Shuttle Sortie operation, as well as the experiment's applicability to the derivation of mission requirements.

From this group, 30 experiments received the fullest, or Level 1, documentation, including a definition of the measurements and observations required, their temporal and spatial characteristics, and the sensor/instrumentation considered necessary in order to accomplish the experimental objectives according to the proposed technical approach. In order to provide a basis for the development of sensor concepts, the documented measurement requirements were considered from the standpoint of spectral regions, spatial and spectral resolutions, sensitivities, fields of view, areal coverage and frequency of observation. Sensor synthesis was an iterative process, with measurement requirements being tempered by considerations of current and projected state-of-the-art technology and the status of current and projected sensor development. Together with Shuttle and Sortie Lab guidelines and constraints and orbital parameters, these concepts were then used to identify, select and define particular sensor configurations and specifications.

This process, leading to a convergence and consonance of acceptable measurement requirements and achievable sensor performance, resulted in the selection of 33 sensors for use in establishing reference missions and conducting conceptual designs of the MEO. Most of the sensors defined in this manner are probably not precisely those which may be flown in MEO Shuttle Sortie missions; neither are their design specifications likely to remain fixed throughout their development. Nevertheless, they can be considered representative for use in the development of engineering, design and mission requirements.

The subsections that follow provide a broad general discussion of the MEO sensors and their characteristics only insofar as they may impact
on the definition of reference missions and on the development of conceptual designs of the MEO. The discussion begins by indicating how the sensors can be categorized according to a general sensor classification scheme, how they are allocated to each Level 1 experiment, and the relationship of the selected sensors to developments of past, current, and planned programs.

Performance characteristics are discussed in terms of spectral regions used, and the cross-track coverage and spatial resolutions attained, while physical characteristics focus on weight and power values.

Finally, the individual sensor classes are evaluated on the basis of their importance to and their frequency of use by all experiments within each MEO discipline.

3.1.1 MEO Sensors and Sensor Classes

The 33 MEO sensors are listed in Table 3-1. Detailed specifications for each sensor are given in Appendix A. Taken as a whole, they constitute a mix of imaging and non-imaging sensors. Among the former are both photographic (i.e., cameras) and non-photographic (e.g., radars, passive microwave radiometers, ultraviolet, visible, and infrared scanners) sensors. Non-imaging sensors include interferometers, some spectrometers and radiometers, the laser altimeter/scatterometer, sferics receiver, visible radiation polarimeter, and the tracking telescope and wide angle/H-α viewer. (The latter two sensors may accommodate a photographic and a TV camera, respectively.)

The sensors operate over a wide region of the electromagnetic spectrum (see Section 3.1.3), ranging from the UV through the visible, infrared, microwave and the UHF, VHF and HF regions. Horizontal resolution capabilities from an orbital altitude of 200 n. mi. range from 4 meters with the laser altimeter/scatterometer to nearly 1000 km with the sferics receiver (see Section 3.1.3).
### Table 3-1. The MEO Sensors

<table>
<thead>
<tr>
<th>No.</th>
<th>Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tracking Telescope</td>
</tr>
<tr>
<td>2</td>
<td>Pointable Identification Camera</td>
</tr>
<tr>
<td>3</td>
<td>Panoramic Camera</td>
</tr>
<tr>
<td>4</td>
<td>Wide-Angle Framing Camera</td>
</tr>
<tr>
<td>5</td>
<td>Multispectral Camera System</td>
</tr>
<tr>
<td>6</td>
<td>High Resolution Multispectral Camera System</td>
</tr>
<tr>
<td>7</td>
<td>Multiresolution Framing Camera</td>
</tr>
<tr>
<td>8</td>
<td>High Resolution Wideband Multispectral Scanner</td>
</tr>
<tr>
<td>9</td>
<td>LWIR Spectrometer</td>
</tr>
<tr>
<td>10</td>
<td>Wideband Synthetic Aperture Radar</td>
</tr>
<tr>
<td>11</td>
<td>Multifrequency Wideband Synthetic Aperture Radar</td>
</tr>
<tr>
<td>12</td>
<td>Laser Altimeter/Scatterometer</td>
</tr>
<tr>
<td>13</td>
<td>Visible Imaging Spectrometer</td>
</tr>
<tr>
<td>14</td>
<td>IR Multispectral Mechanical Scanner</td>
</tr>
<tr>
<td>15</td>
<td>High Resolution Visible Imaging Spectrometer</td>
</tr>
<tr>
<td>16</td>
<td>High Resolution IR Multispectral Scanner</td>
</tr>
<tr>
<td>17</td>
<td>Glitter Framing Camera</td>
</tr>
<tr>
<td>18</td>
<td>Star Tracking Telescope</td>
</tr>
<tr>
<td>19</td>
<td>UV Upper Atmosphere Sounder (UVUAS)</td>
</tr>
<tr>
<td>20</td>
<td>Visible Radiation Polarimeter (VRP)</td>
</tr>
<tr>
<td>21</td>
<td>Air Pollution Correlation Spectrometer</td>
</tr>
<tr>
<td>22</td>
<td>High Speed Interferometer (HSI)</td>
</tr>
<tr>
<td>23</td>
<td>Carbon Monoxide Pollution Experiment (COPE)</td>
</tr>
<tr>
<td>24</td>
<td>Cloud Physics Radiometer (CPR)</td>
</tr>
<tr>
<td>25</td>
<td>Remote Gas Filter Correlation Analyzer (RGFCA)</td>
</tr>
<tr>
<td>26</td>
<td>Advanced Limb Radiance Inversion Radiometer (ALRIR)</td>
</tr>
<tr>
<td>27</td>
<td>TIROS-N Advanced Very High Resolution Radiometer (AVHRR)</td>
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<tr>
<td>28</td>
<td>TIROS-N Operational Vertical Sounder (TOVS)</td>
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<tr>
<td>29</td>
<td>Passive Microwave Radiometer (PMMR)</td>
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<tr>
<td>30</td>
<td>Microwave Radiometer/Scatterometer</td>
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<tr>
<td>31</td>
<td>Sferics Receiver</td>
</tr>
<tr>
<td>32</td>
<td>Wide Angle Viewer/Hydrogen Alpha Line Viewer</td>
</tr>
<tr>
<td>33</td>
<td>Data Collection System</td>
</tr>
</tbody>
</table>

3-3
Table 3-2 shows how the Level I experiment requirements documented in the study Task 1 report are satisfied with the MEO sensors. It can be seen that a meaningful sensor package for each Level I experiment (with the exception of M2) consists of a varied, but selected group of sensors. Several sensors (1, 2 and 32) find essentially universal use by the experiments. The camera systems find the widest use, while a number of the sensors (e.g., 19, 21, 22, 23, 25 and 26) required in experiment M4 are experiment-unique.

Most of the sensors fulfill multidisciplinary requirements, although 15 (or 45 percent) are used in a single discipline only. For example, sensors 15 and 16 (which are high-resolution versions of sensors 13 and 14) are used only in two of the Oceanography experiments. One sensor (the LWIR spectrometer, 9) finds use only in the Geology experiments, while 11 sensors are used only in Meteorological experiments. Of these 11 sensors, one (the star-tracking telescope, 18) is the only sensor required for experiment M2, six find their use only in the experiment dealing with air pollution monitoring (M4), and one (24) is used only in experiment M5 which is concerned with weather modification experiments.

The MEO sensors can be grouped or classed in various ways—on the basis of their usage by the various experiments, by spectral regions in which they operate, according to their mode of operation (i.e., scanning or not), etc. The grouping shown in Table 3-3 is based on sensor type, and is indicative of the broad range of sensors that have been selected and defined during this study.

3.1.2 Sensor Selection Sources

The MEO sensors can be traced to a variety of sources and programs as shown in Figure 3-1. In many cases, the definition of sensors presents a logical extension of an existing, or soon to be developed, capability. The panoramic camera, for example, has already been successfully flown on the last three Apollo missions and would require only minor modifications for the MEO. Others have already been developed (e.g., for the SKYLAB program), expand on these developments, are currently in various stages of development, or have been proposed for development under other programs such as AAFE, TIROS-N, and EOS, and could be ready for use on early Shuttle Sortie missions. Several
Table 3-2. MEO Sensor Allocation to Level 1 Experiments

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<thead>
<tr>
<th>Sensor</th>
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50 n resolution

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12 co:(5 fn.) fflm

66 m. (24 in.) f.l.

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5 m resolution
WIDE ANGLE FRAMING CAMERA
24 x 48 cm. ( 9 x T8 In.) film

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30 cm, (12 in.) f.l.
20 m resolution

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RULTISPECTRAL CAMERA SYSTi:n
9 x 9 in,) film
24 x 24 cas
, olor, and false color)
Six cameras four R .
46 cm. (18 in,) f.l. ,. 1B5 Kn (lOD n.m[.) coverage
25 m resolution

`n

HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM

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X X X

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(70 m film)
Six
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HULTIRESOLUTION FRAMING CAMERA SYSTEM
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Three cameras, false color film only

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46, 92, 184 cm. 118, 36, 72 in,} F.1.
25, 12, 6 n resolution
HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER

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30160 n resolution (20 Spectral Bands)

LWIR SPECTROMETER

(6.2-l5.5µ,0.4-2.41e)

( NBSAR)
(Wide Coverage, Low Resolution Mode)

WIDEBAND SYNTHETIC APERTURE RADAR

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( WBSAR)
(r"edium Coverage, High Resolution Mode)

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WIOEBAND SYNTHETIC APERTURE RADAR

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MULT(FAEQUENCY WIOEBA1lD SYNTHETIC APERTURE RADAR
( MFRBSAR)

X

^i

(Medium Coverage. Low Resolution Mode)

^y
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HULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR
(MFH85AR)

X X

(Narrow Coverage, High Resolution Mode)

LASER ALTIMETER / SCATTEROMETER

X

X

X

x x x

x

!V
VISIBLE [RAGING SPECTROMETER

X

X

X X

^X

X X

(Ocean Color Measurement)

IR MULTISPECTRAL MECHANICAL SCANNER

X

X

X

(Ocean Surface Temperature Measurement)

^+

L7t

X

HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER

x

X

(Ocean Color Med3Ur Cment)

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Table 3-2. MEO Sensor Allocation to Level 1 Experiments

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*Note: The table contains various scientific instruments and their corresponding data collection systems.*
Table 3-3. MEO Sensors/Classes
(Numbers in Parenthesis Correspond to List in Table 3-1)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
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</table>
| TELESCOPES,VIEWER               | • Tracking Telescope (1)  
• Star Tracker (18)  
• Wide Angle H-α Line Viewer (32) |
| CAMERAS                         | • Pointable Identification (2)  
• Panoramic (3)  
• Wide Angle Framing (4)  
• Multispectral (5, 6)  
• Multiresolution Framing (7)  
• Glitter (17) |
| MULTISPECTRAL SCANNERS          | • High Resolution Wideband (8)  
• IR Mechanical (14, 16) |
| SPECTROMETERS                    | • Long Wave IR (Also Radiometer) (9)  
• Visible Imager (13, 15)  
• UV Upper Atmosphere Sounder (19)  
• Air Pollution Correlation (21) |
| SFERICS                         | • HF, VHF, UHF Receiver (31) |
| OPTICAL CORRELATION             | • Gas Filter Correlation Analyzer (25) |
| INTERFEROMETERS                  | • High Speed (22)  
• Carbon Monoxide Pollution (23) |
| RADIOMETERS                      | • Cloud Physics (24)  
• Advanced Limb Radiance Inversion (26)  
• TIROS-N Advanced Very High Resolution (27)  
• TIROS-N Operational Vertical Sounder (28)  
• Passive Multichannel Microwave (29)  
• Microwave Radiometer/Scatterometer (30) |
| RADARS                          | • Wideband Synthetic Aperture (10A, 10B)  
• Multifrequency Wideband Synthetic Aperture (11A, 11B) |
| LASER                           | • Altimeter/Scatterometer (12) |
| POLARIMETER                     | • Visible Radiation (20) |
| DATA COLLECTION SYSTEM          | (33) |

3-7
Figure 3-1. MEO Sensor Selection Sources
sensors have their roots in the AAP-A program and their development lies within the state of the art. A number of sensors are defined as extensions of those that have already proven themselves operationally useful in aircraft (e.g., sensors 4, 5, 7, 10, 11, 21, 32). A few sensors (14, 16, 17) are not directly traceable to any particular program; however, their development seems to be within the available state of the art.

Some sensors will require major development in order to bring them to the point where they can be flown on the MEO. Included in this group are the synthetic aperture radars, the passive multichannel microwave radiometer, and the microwave radiometer/scatterometer.

3.1.3 Performance Characteristics

3.1.3.1 Spectral Regions

The spectral regions used by each MEO sensor and the corresponding spectral range are shown in Figure 3-2 and 3-3. Taken as a group, they range over eight orders of magnitude from the near-UV to the HF region of the radio spectrum.

In the shorter wavelengths (0.2 - 4μm), the sensors respond primarily to reflected solar radiation, while in the far-IR and microwave regions the sensors detect upwelling radiation from the earth's surface and the atmosphere (i.e., thermal emission). In the intermediate wavelengths (from approximately 4 - 6μm), both reflected and emitted radiation are detected. Therefore, observations of reflected solar radiation depend on the amount of energy received and reflected by the object being observed, while observations made in the thermal wavelengths are functions of the object's temperature and its emittance. This characteristic, taken together with the nature of the object or phenomena being observed, permits the use of sensors (either singly or in conjunction with one another) which are sensitive to different portions of the electromagnetic spectrum.

Photographic film limits the most common of optical imaging sensors--the cameras--to spectral regions from the near-UV to the near-IR. As a result, these sensors are not operable during nighttime or under very low light level conditions. When clouds, smoke, fog or haze intervene, "seeing" may be particularly difficult and oftentimes impossible.
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<th>VIS</th>
<th>IR</th>
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<td>UV UPPER ATMOS SOUNDER</td>
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<td>AIR POLL CORREL SPECT CAMER A</td>
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<td>HIGH SPEED INVERFER CAMER A</td>
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<td>CLOUD PHYSIC RAD CAMER A</td>
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<td>GAS FILTER CORREL CAMER A</td>
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<td>PASSIVE MICROWAVE RAD CAMER A</td>
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<td>MICROWAVE RAD/SCAT CAMER A</td>
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**Figure 3-2. MEO Sensors Spectral Region Usage**
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<th>INSTRUMENT</th>
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<th>MIDDLE IR</th>
<th>FAR IR</th>
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WAVELENGTH

0.1 \mu m
1 \mu m
10 \mu m
100 \mu m
0.1 cm
0.001 cm
0.01 cm
300 GHz
30 GHz

FOLDOUT FRAME
### Figure 3-3. Spectral Range of MEO Sensors (Numbers Correspond to List in Table 3-1)
The non-photographic imaging sensors detect reflected and/or emitted radiation from surface features and phenomena or from the atmosphere. They operate in spectral regions which range from the UV to the microwave. The IR, radar, and passive microwave sensors are not restricted to daytime operations and in almost all instances the radars (10 and 11) are not seriously hindered by intervening clouds or precipitation. On the other hand, the passive multichannel microwave radiometer (29) has been configured to detect precipitation as well as to detect surface features in the presence of precipitation.

3.1.3.2 Spatial Resolution

Resolution is an important parameter in describing the performance of earth observations sensor systems. It is measurable, fundamental, and is widely discussed; but its use is difficult and often misunderstood, and its limitations are not generally appreciated.

As used originally by astronomers, "resolution" described the ability of a telescope to separate double stars. As it has come to be applied over the years to photographic systems, resolution refers to the ability of a film or a lens, or a combination of both, to render barely distinguishable a standard pattern consisting of black and white lines. When the resolution of a system is said to be 60 lines (or line pairs) per millimeter, it is meant that the pattern whose line-plus-space width is 0.1 mm is barely resolved, that finer patterns are not resolved and that coarser patterns are more clearly resolved.

Criticism of the use of this single parameter to specify performance is justifiable, for it fails to describe the character of the resolution at all points other than the last, or threshold, value. Nevertheless, it is a convenient measure, useful in making gross comparisons and evaluations.

It is possible to test film and obtain resolution values essentially independent of the lens, and lenses may be visually tested without film. A reliable way to assess the combined effects of film and lens is to use the threshold resolution values of the film and the lens and then add the reciprocals of these values as follows:

\[
\frac{1}{R_{F+L}} = \frac{1}{R_F} + \frac{1}{R_L},
\]
where \( R_F \) and \( R_L \) are the resolution in lines per millimeter, of the film and the lens, respectively.

This simple, essentially heuristic, reciprocal formula can be generalized to include terms chargeable to the atmosphere, image motion, film processing and handling, and the like. Thus, more generally, the resolution \( R_S \), of a given system \( S \), is given by

\[
\frac{1}{R_S} = \sum_{i=1}^{n} \frac{1}{R_i}
\]

where \( R_i \) represents the resolution limits of the \( n \) separate components.

Ground, or spatial resolution, is a familiar term in all discussions of earth observation sensor performance. It is simply the ground resolution equivalent to one line at the limit of resolution. Thus, if a given system yields \( R \) lines per millimeter, and the scale number (the altitude divided by the focal length of the system) is \( S \), the ground resolution (in familiar units and rounding off slightly) is given as:

\[
\text{Ground resolution (ft)} = \frac{S}{300R}.
\]

Consider the example of the wide-angle framing camera (Sensor No. 4), with a 12-inch focal length lens, viewing vertically at 200 n.mi. The scale number is 1,216,000. At 60 lines per millimeter, the ground resolution would be approximately

\[
G = \frac{1,200,000}{300 \times 60} = 67 \text{ ft (20m)}
\]

Non-photographic imaging sensors, as well as non-imaging sensors have spatial resolutions determined by their instantaneous field of view (IFOV).

Figure 3-4 shows the horizontal, or ground, resolution provided by the MEO sensors (details are found in Appendix A).

Values for the telescope and viewer are based on observer vision through the sensor eyepiece with a target having an apparent contrast of 2:1.
Figure 3-4. Horizontal Resolution Provided by MEO Sensors
(At Nadir and 200 n. mi. Altitude)
The ground resolutions of the high-quality photographic systems are from 5 to 50m, which from an altitude of 200 n. mi. (370 km) corresponds to angular resolutions of from 3 sec to 30 sec. of arc. The air pollution sensors (polarimeter, correlation spectrometer, interferometers, gas filter optical correlation analyzer) have angular resolutions which are typically of the order of tenths of a degree to several degrees.
3.1.3.3 Cross-Track Coverage

The MEO sensors, designed to operate at altitudes specified in the Level 1 experiment requirements documentation, have varying fields of view and viewing angles (see Appendix A). Because of the relatively short duration of the 7-day Shuttle Sortie mission, target availability and target coverage with non-pointing sensors would be minimal. Therefore, in order to increase the amount of useful data on any given orbital pass, most of the sensors have been provided with an off-nadir pointing capability, using either one-axis or two-axis gimballed platforms.

The total angular cross-track coverage provided by the MEO sensors taken as a whole is shown in Figure 3-5. Five sensors provide coverage to more than 60° off-nadir (Note: At a Shuttle altitude of 200 nautical miles, the earth's limb, or horizon, is approximately 71° off-nadir, corresponding to a ground distance from the Shuttle sub-point of approximately 1150 nautical miles), while only two sensors — the laser altimeter/scatterometer, 12, and the carbon monoxide pollution sensor, 23 — provide less than ±15° off-nadir coverage. Several sensors (19 and 26) utilize the limb — pointing mode, with the sensor pointing towards the earth's horizon, and scanning taking place in the vertical, allowing vertical profile measurements to be made of thermally emitted or solar scattered energy from a narrow region of the atmosphere. The synthetic aperture radars (10 and 11) have fields of view ranging from 8.6° to 14.5°, and look only to one side, either 30° or 56° off-nadir.

3.1.4 Physical Characteristics

Figure 3-6 shows the range and distribution of MEO sensor weights. The multifrequency wideband synthetic aperture radar, 11, weighs 945 kg and the multispectral, 18-inch focal length camera system, 5, (six cameras with 9 in. x 9 in. formats) weighs 760 kg.

When the weight of gimballed platforms required to point individual sensors is added to the sensor weights, the redistribution of MEO sensor weights are as shown in Figure 3-7. The multispectral camera system (5) now becomes the heaviest sensor (1124 kg). Twenty-one, or nearly two-thirds, of the sensors each weigh less than 100 kg, and 45 percent weigh less than 40 kg each.
Figure 3-5. Total Angular Cross-Track Coverage by MEO Sensors
Figure 3-6. MEO Sensor Weights

Figure 3-7. MEO Sensor Weights Including Gimbals
Figures 3-8 and 3-9 show the range and distribution of average power used by the MEO sensors, with Figure 3-9 reflecting the increased power chargeable to the sensors that comes with the addition and use of gimballed platforms to point the sensors. More than one-half of the sensors will require less than 100 watts, and almost three-quarters of the sensors will operate with less than 200 watts average power. The multispectral camera system (5) and the synthetic aperture radars (10 and 11) each require approximately 2000 watts. The microwave sensors (29 and 30), the camera systems (3, 4, 7) and the high resolution multispectral scanner (8) each operate at more than 200 watts average power, with the multi-resolution framing camera (7) requiring 1000 watts in the operation of its large format, various focal length system.

3.1.5 Evaluation of Sensor Usage

Figure 3-10 shows how the Level 1 experiments for each earth observation discipline use the various classes of MEO sensors. The number assigned to each box in the matrix is the synthesis of an evaluation based on three separate and mutually exclusive factors, namely:

1) The fraction of experiments (within each discipline) that use some or all of the sensors in a given class

2) The importance of the sensor class to the experiments within a discipline—from the standpoint of obtaining useful and important data

3) The fraction of sensors (making up a sensor class) used by the experiments within each earth observation discipline.

Only the important combinations of these factors have been keyed in order to illustrate the sensor vs experiment usage. The numbers do not constitute a strict rating system, although a 1, with all factors reflecting large fractions and high values, certainly deserves more attention than a 4, with all factors reflecting low fractional usage and lower importance.

Numbers 1 and 3 find wide usage among the experiments in a discipline. Numbers 1 and 2 indicate that a large fraction of the sensor class is used by the experiments in a discipline and that they are of high value to the experiment. Numbers 2 and 4 indicate that the sensor class is used by less than one-half of the experiments in a discipline. Numbers
Figure 3-8. Average Power Used by MEO Sensors

Figure 3-9. Average Power Used by MEO Sensors Including Gimbals
<table>
<thead>
<tr>
<th>SENSOR CLASS (No. of Sensors in Class)</th>
<th>EXPERIMENT DISCIPLINES</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>TELESCOPIES/VIEWERS (7)</td>
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<tr>
<td>OCEANOGRAPHY</td>
<td>1</td>
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<tr>
<td>METEOROLOGY</td>
<td>1</td>
</tr>
<tr>
<td>AGRICULTURE/FORESTRY/RANGELANDS</td>
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<td>OTHERS</td>
<td>1</td>
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<tr>
<td>NO. OF EXPTS. USING SENSOR CLASS</td>
<td>30</td>
</tr>
</tbody>
</table>

**Key**

1 = Used in ≥50% of expts; high value to expts; large fraction of sensor class used.

2 = Used in <50% of expts; high value to expts; large fraction of sensor class used.

3 = Used in ≥50% of expts; less important to expts; smaller fraction of sensor class used.

4 = Used in <50% of expts; less important to expts; smaller fraction of sensor class used.

Figure 3-10. MEO Experiments and Sensor Usage (30 Experiments, 33 Sensors)
3 and 4 indicate that a smaller fraction of the sensors in a sensor class are used by the experiments in a discipline and that they are of secondary importance to the experiment.

What is definitely indicated by this analysis is that the telescope and wide-angle viewer and most of the camera systems are important to and find universal or near-universal usage by the MEO experiments. Interferometers are used only in a small fraction of the meteorological experiments although they are of high value to the experiment in which they are used. Radars are widely used and important to most of the geology and hydrology experiments.

The number of experiments using one or more sensors from a class of sensors is indicated on the lower line. Again, the visual sensors and the cameras are universally used (if the Stellar Occultation experiment, M2, is for this purpose not included). One or more of the three multispectral scanners are used on almost two-thirds of the experiments, and more than one-third of the experiments make use of one or more of the six radiometers. The meteorological experiments are the only users of the interferometer and the sferics receiver, with the interferometers being used on only one and the sferics receiver on only two of the six experiments documented for this discipline.
3.2 APPLICATION OF COMPUTER PROGRAMS

3.2.1 Introduction

The analysis of reference missions is accomplished by using TRW and MSFC computer programs. These programs include:

**MSFC**
- OTO: Orbit Track Optimization
- PACER: Percent Area Coverage, Earth Resources
- AESOP: Automatic Experiment Scheduling and Optimization Program

**TRW**
- ILLUM: Illumination
- RISET: Rise and Set Times (Data Stations)
- CARTOG: Cartography

The operation and sequencing of these programs is shown in Figure 3-11. Beginning with the reference mission requirements (which included experiment measurement/observation requirements, sensor characteristics and Shuttle Sortie constraints), the high priority reference missions were analyzed using a sequenced set of computer programs to derive the mission requirements for a Manned Earth Observatory.

3.2.2 Program Descriptions

3.2.2.1 Percent Area Coverage, Earth Resources (PACER) Program (MSFC)

The PACER program is used to calculate the percent of a given area covered in a given period of time by an orbiting sensor with a specified field of view. The sensor is assumed to be in a "drag-free" circular orbit with a constant nodal regression rate. The only constraint that may be placed upon the sensor observation is a lighting or illumination constraint which is defined as an upper and lower bound on the solar elevation angle at the subsatellite point.

The program employs a combination of vector mechanics and spherical trigonometry to obtain solutions. The portion of an area that is covered in a specified period of time is calculated by approximate integration.

An evaluation of orbits for earth mapping sensors/missions in which emphasis is placed upon covering as much of a given target area as
Figure 3-11. Mission Analysis Program Relationships
possible can be accomplished by use of the PACER program. The program can also be used to optimize the orbit altitude, inclination and launch time of day by performing parametric studies.

3.2.2.2 Orbit Track Optimization (OTO) Program (MSFC)

The basic purpose of the OTO program is to determine an optimal orbit for an earth observations mission in which the frequency of target coverage is to be maximized. This is accomplished by determining the altitude, inclination and phasing of an orbit that maximizes the total number of passes over a specified set of targets on the Earth's surface. A target may be anything from a point site to a bounded area, and is input into the program in terms of latitudes and longitudes.

Unlike the PACER program, OTO considers the effect of aerodynamic drag on the number of times the satellite passes over the targets. Nodal regression and the movement of the sun in the ecliptic are included in the simulation. A solar elevation angle constraint can be imposed so that target passes are not counted if the constraint is violated.

Once an orbit is selected, OTO is used to determine the target acquisition and loss times. These times are registered on an ephemeris tape which can be used in scheduling studies.

3.2.2.3 Cartography (CARTOG) Program (TRW)

The purpose of the CARTOG program is to plot charts of the world using the CALCOMP plotters. The charts may be plotted depicting the whole world or subsections thereof. The basic premise behind constructing the program was to allow every option of the program to be completely independent of the other features, thus allowing the program to be completely modular. Additionally, the program was constructed so that the inputs describe a series of overlays to the charts. These overlays may be data developed within the program or constructed by some other program and then overlayed on the chart.

Additional features of this program include:

- Trajectory traces
- Trajectory swaths
- Earth horizon lines
- Tracking Station visibility circles for circular orbits
- Satellite down link antenna footprints
- Lines of constant range contours
- Lines of constant latitude and longitude emanating from an arbitrary point
- Trajectory traces generated by external programs.

The projections available are:

- Cylindrical family
  - Uniform grid
  - Mercator

- Conic family
  - Lambert conformal
  - Gonigraphic
  - Transverse mercator
  - Oblique mercator

- Azimuthal family
  - Azimuthal equidistant
  - Azimuthal equidistant sector
  - Stereographic
  - Orthographic

- Kepler double map.

3.2.2.4 Illumination (ILLUM) Program

This program plots the solar illumination angle as a function of days from vernal equinox for a variety of latitudes. It informs the user of those geographical areas that have acceptable sun angles for the sensors being considered. The portion of an orbit with acceptable sun angles can therefore be plotted over the entire coverage cycle.

3.2.2.5 Data Station Rise and Set Times (RISET) Program (TRW)

RISET is a Fortran program developed for use on the CDC 6500 Computer to generate a rise (acquisition) and set (loss) time history for a specified orbit, ground station network and elevation angle. The output may be printed and/or plotted on Calcomp Plotters. The printed output is a history of station rise and set times and the duration of the observation time per orbit revolution. The plotted output is a graph of the printed output of station vs time and station review.
As an additional option, CARTOG may be used to generate a plot time history of the station rise and set times for the mission orbit and data station network over a selected projection of the earth.

3.2.2.6 Automatic Experiment Scheduling and Optimization Program (AESOP) (MSFC)

AESOP generates a prescribed number of feasible experiment/sensor schedules along with the total requirements of specified parameters including electrical power, data requirements, etc. A time history of resource utilization is simultaneously generated with each schedule and specific resource requirements (e.g., average electrical power) are automatically summarized with appropriate histograms and time histories.

Fundamental to the operation of AESOP is the understanding of several terms:

- **Experiment** — An activity involving one or more sensors dedicated to one application (e.g., air pollution monitoring)

- **Event** — A sensor activity with constant resource and constraint requirements (e.g., set up, operate, and calibrate)

- **Constraint Requirements** — Nondepletable factors which limit the time interval available for an event (e.g., illumination conditions and tracking station visibility)

- **Resource Requirements** — Items which may or may not be depletable. A skill requirement is depleted only if demand exceeds availability and even then, only as long as the demand exists. Film, on the other hand, is available in a fixed quantity and cannot be reused; therefore, it is depletable.

AESOP is composed of three main sections. Section I initiates the scheduling process by merging the ephemeris requirements (targets, lighting, etc.) for each sensor event with the start/stop times for ephemeris conditions derived for the mission by the OTO Program. The output of this section is the initial candidate interval timeline. Section II merges the event resource requirements and resource availability with the start/stop times of event resource availability. It also merges the initial candidate interval timeline with the resource availability timeline and eliminates intervals where resources are not available. The resulting start/
stop times are the final event candidate intervals. In Section III a random search is conducted using a Monte-Carlo technique to order the schedule and select the start time for each event. Included in this search are the following considerations:

- Event priority ordering requirement
- Repeat performance requirements
- Precedent requirements.

This process is reiterated until all events have been scheduled.

In terms of mission planning, the program has a variety of uses:

- N feasible schedules can be computed and compared
- The interdependence of schedule parameters
- The effect of weighted parameters on the schedule
- Mission support requirements
- Mission compatible experiments.
3.2.3 Program Application

3.2.3.1 Orbital Optimization Programs (OTO and PACER)

The selection of an orbit for a MEO reference mission was governed by the requirements of the mission experiments:

- Target locations and sites
- Observation frequencies desired/acceptable
- Altitude range desired/acceptable
- Illumination considerations
- Coverage requirements

The target locations and sites were specified in terms of latitude and longitude ranges (areas were defined using rectangles). Observation frequencies were expressed as the desirable and acceptable number of looks or sightings per day. The desirable and acceptable altitude ranges were expressed in nautical miles. The illumination constraints were specified in terms of solar elevation angle and time of year. The final specification was which program should be used. The experiment inputs are in Appendix B.

In addition to the orbital selection constraints imposed by the requirements of the mission experiments, only circular orbits were considered, and mapping and high frequency coverage could not be simultaneously considered.

As shown in Figure 1-1, only the first four reference missions were carried through an orbital analysis. Since all the experiments within each of the four missions had a strong frequency of coverage requirement (1 look/2 days), OTO was used to select the mission orbits. The results are depicted in Figure 3-12. Reference missions 1, 2, and 4 are similar in a number of ways:

- Moderate to low latitude targets resulted in inclinations between 40 and 50 degrees and an altitude of approximately 180 nautical miles.

- Each mission could be flown from an ETR launch (inclusion < 59°).

The Oceanography/Meteorology Reference Mission (Priority Number 3) varied somewhat from the others in terms of orbital parameters because
## INPUT
- TARGET AREA/LOCATION
- OBSERVATION FREQUENCY
- ALTITUDE RANGE
- ILLUMINATION CONSTRAINTS
- OPTIMIZATION:
  MAPPING
  FREQUENCY

## OUTPUT

<table>
<thead>
<tr>
<th>REF MISSION PARAMETER</th>
<th>POLLUTION 1*</th>
<th>ENVIR 2*</th>
<th>OCEAN./MET 3*</th>
<th>SPRING 4*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTITUDE (N MI)</td>
<td>183</td>
<td>183</td>
<td>199</td>
<td>180</td>
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<td>INCLINATION (DEG)</td>
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<td>107</td>
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<td>ETR</td>
<td>WTR</td>
<td>ETR</td>
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* MISSION PRIORITIES

Figure 3-12. The Results of the Orbital Optimization
of a strong requirement to cover the $68^\circ - 72^\circ$ latitudinal belt every two days in the Ice in the Southern Ocean experiment (see Volume 1 and Appendix B, Experiment M6). This requirement necessitated a WTR launch, an inclination of $70^\circ$ and an altitude of 199 nautical miles.

To meet the illumination requirements and target phasing the right ascension of the ascending node ranged from $107^\circ$-$134^\circ$ West.

3.2.3.2 Orbit Evaluation Using the CARTOG, ILLUM and RISET Programs

Since the first priority reference mission, pollution, was to be carried through experiment scheduling, its orbit was subjected to a re-evaluation using the CARTOG, ILLUM and RISET computer programs.

Assuming that it takes one day for the Shuttle Orbiter to reach an operational orbit position and one day to shut down the experiments and return to the earth, there are five days in a Shuttle Sortie flight to complete a reference mission. The CARTOG program was used to plot a five day trajectory subsatellite time history on a specified projection of the earth. (See Figures 3-13 through 3-17). An enlargement of the Continental United States is shown in Figure 3-18, to illustrate the sizes and distribution of pollution mission targets. These coverage plots were used to determine if there were any additional targets that were covered by the selected orbit and should be considered in the mission. The study team disciplinarians decided that no additional targets should be added to the mission.

The ILLUM program was used to re-evaluate the sun elevation angle constraints on the experiment targets. For a launch date of May 4 and an initial right ascension of the ascending node of $118^\circ$ all the northern latitudes (and therefore all the mission targets) have a sun angle greater than or equal to $30^\circ$ which satisfies the initial constraint.

Using the Manned Spaceflight Network (MSFN) as ground stations and assuming a $10^\circ$ readout circle, the pollution mission was evaluated in terms of the frequency and duration of possible data dumps. This was accomplished through the use RISET and CARTOG. RISET was used to generate an acquisition and loss timeline and CARTOG was used to plot the time history. As shown in Figure 3-19, 2-minute trajectory tick marks were used to indicate time and a $10^\circ$ readout circle was plotted.
Figure 3-13. First Day's Ground Trace Pattern for the Pollution Reference Mission—Evaluated for Additional Targets
Figure 3-14. Second Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets
Figure 3-15. Third Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets
Figure 3-16. Fourth Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets
Figure 3-17. Fifth Day's Ground Trace Pattern for the Pollution Reference Mission--Evaluated for Additional Targets
Figure 3-18. A U.S. CARTOG Plot Evaluated for Coverage of Additional Targets
Figure 3-19. Readout for Typical Day in the Pollution Reference Mission
for each data station to indicate trajectory rise and set times. The result of these runs are discussed in detail in Section 4.

3.2.3.3 Experiment Scheduling (AESOP)

The inputs needed to run AESOP are shown in Figure 3-20. The sensor data bank consists of a resource requirements/sensor events matrix, a sequencing matrix and a list of operational priorities. The requirements matrix shows the distribution of resource requirements over the event of each mission sensor. The resource requirements of the high resolution visible imaging spectrometer (sensor number 15) are shown in Figure 3-21. The remaining resource requirements matrices may be found in Appendix C. The sequencing matrix shows all the possible event sequences for an instrument. This can also be expressed in a flow diagram as shown in Figure 3-22 for Sensor 15. The remaining sequencing matrices may also be found in Appendix C. For example, set up can only be followed by calibrate, whereas calibrate can be followed by standby or operate depending on whether or not the sensor can acquire an experiment target. The operation priorities are used as decision logic when more than one alternative exists in terms of event sequencing and when an event must be instituted periodically (time interval-dependent, not sequencing-dependent).

The mission experiment priorities were based upon a three level evaluation:

- **Priority 1**
  - Experiment closely relates to the central theme of the mission (phenomena, time of year, location).
  - Singular hemispheric time of year required.
  - Combination of experiments (complementary data and time-sharing of sensors).

- **Priority 2**
  - Less crucial to central theme of mission.
  - Not restricted to specific time of year.

- **Priority 3**
  - Add on/filler with respect to sensor use, target locations, weight/power, etc.
Figure 3-20. A Variety of Inputs are Required to Run AESOP
1) PHYSICAL REQUIREMENTS

| Size: \(0.012 \text{ m}^3 (0.43 \text{ ft}^3)\) | SENSOR
| \(0.006 \text{ m}^3 (0.23 \text{ ft}^3)\) | GIMBALS

| Weight: \(13.6 \text{ kg} (30 \text{ lb})\) | SENSOR
| \(11.4 \text{ kg} (25 \text{ lb})\) | GIMBALS

| Power: | \(25 \text{ W}\) | SENSOR
| \(25 \text{ W} \text{(AV)}, 100 \text{ W} \text{(PK)}\) | GIMBAL

2) REQUIREMENTS

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>EVENTS</th>
</tr>
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<tbody>
<tr>
<td>SET UP/ MODIFICATION</td>
<td>CHECKOUT CALIBRATION</td>
</tr>
<tr>
<td>DURATION (STANDARD, OR MIN/MAX)</td>
<td>10 MIN (\text{ (WARM-UP)})</td>
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<tr>
<td>POWER</td>
<td>50 W</td>
</tr>
<tr>
<td>DATA</td>
<td>-</td>
</tr>
<tr>
<td>FILM</td>
<td>-</td>
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<tr>
<td>MANPOWER</td>
<td>1/2</td>
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3) CONFLICTS WITH OTHER SENSORS: NONE

Figure 3-21. The Resource Requirements for Sensor 15, High Resolution Visible Imaging Spectrometer
EVENTS
1. SET UP
2. CALIBRATE
3. OPERATE
4. STANDBY
5. SHUTDOWN

OPERATION PRIORITIES
- CALIBRATE OCCURS ONCE/2 DAYS
- SHUTDOWN OCCURS AT THE END OF THE LAST OPERATE

Figure 3-22. Event Sequencing for Sensor 15, High Resolution Visible Imaging Spectrometer
Absolutely neutral with respect to time of year and/or geographic location of targets.

The experiment priorities for the pollution reference mission are:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Priority</th>
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<tbody>
<tr>
<td>Regional water pollution monitoring</td>
<td>1</td>
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<tr>
<td>Air pollution monitoring</td>
<td>1</td>
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<tr>
<td>Lake Eutrophication studies</td>
<td>1</td>
</tr>
<tr>
<td>Coastal geology and geomorphic processes</td>
<td>2</td>
</tr>
<tr>
<td>Urban survey</td>
<td>2</td>
</tr>
<tr>
<td>Geologic and topographic mapping</td>
<td>2</td>
</tr>
<tr>
<td>International development project</td>
<td>2</td>
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<td>Stellar occultation</td>
<td>3</td>
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<tr>
<td>Wildlife-ecosystem studies</td>
<td>3</td>
</tr>
</tbody>
</table>

The final input required to run AESOP is an ephemeris tape. This tape is supplied by the OTO program. An example of the tape is shown in Table 3-4. The targets are consecutively numbered for all the experiments.

The output of AESOP consists of experiment schedules and resource summaries as shown in Figure 3-23. The pollution mission experiment and sensor timelines for a two day coverage cycle are displayed in Appendix D. A detailed power timeline is also shown in Appendix D. A summary of the power requirements is shown in Figure 3-24, as well as an example of an operating period. The electrical power presently baselined to be available in the Sortie Lab for payload usage (exclusive of that available to the payload from the orbiter) is:

- Average 7 kW
- Peak 10 kW for 6 minutes
- Peaking power kit(s) (tentative).

As shown in Figure 3-24, during operating periods the sensors require almost all the power available. This difficulty will be discussed in Section 5 and in Volume III - Section 7.0.

The data requirements, both digital and film, are tabulated in Tables 3-5 and 3-6, respectively. These data requirements are for a
Table 3-4. Ephemeris Tape for Pollution Reference Mission

<table>
<thead>
<tr>
<th>TIME FROM LAUNCH</th>
<th>ENTER/EXIT</th>
<th>EXPERIMENT</th>
<th>TARGET</th>
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<tr>
<td>24.205</td>
<td>ENTER</td>
<td>OT3</td>
<td>80</td>
</tr>
<tr>
<td>24.218</td>
<td>EXIT</td>
<td>OT3</td>
<td>80</td>
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<tr>
<td>24.261</td>
<td>ENTER</td>
<td>O1</td>
<td>80</td>
</tr>
<tr>
<td>24.282</td>
<td>EXIT</td>
<td>O1</td>
<td>80</td>
</tr>
<tr>
<td>24.283</td>
<td>ENTER</td>
<td>M4</td>
<td>28</td>
</tr>
<tr>
<td>24.290</td>
<td>ENTER</td>
<td>M4</td>
<td>27</td>
</tr>
<tr>
<td>24.295</td>
<td>EXIT</td>
<td>M4</td>
<td>28</td>
</tr>
<tr>
<td>24.297</td>
<td>ENTER</td>
<td>G2</td>
<td>121</td>
</tr>
<tr>
<td>24.303</td>
<td>EXIT</td>
<td>M4</td>
<td>27</td>
</tr>
<tr>
<td>24.308</td>
<td>EXIT</td>
<td>G2</td>
<td>121</td>
</tr>
<tr>
<td>24.311</td>
<td>ENTER</td>
<td>G2</td>
<td>122</td>
</tr>
<tr>
<td>24.320</td>
<td>ENTER</td>
<td>O1</td>
<td>15</td>
</tr>
<tr>
<td>24.324</td>
<td>ENTER</td>
<td>OT3</td>
<td>62</td>
</tr>
<tr>
<td>24.325</td>
<td>ENTER</td>
<td>M4</td>
<td>34</td>
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</table>
Table 3-5. Pollution Mission Digital Data Requirements for Each Coverage Cycle

<table>
<thead>
<tr>
<th>SENSOR</th>
<th>RATE</th>
<th>ACTUAL TIME</th>
<th>DATA TAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>200 MB/S</td>
<td>1.748 HR</td>
<td>1.26 x 10^6 MB</td>
</tr>
<tr>
<td>9</td>
<td>6.94 KB/S</td>
<td>860 SEC</td>
<td>5.97 MB</td>
</tr>
<tr>
<td>12</td>
<td>150 B/S</td>
<td>1.353 HR</td>
<td>0.73 MB</td>
</tr>
<tr>
<td>13</td>
<td>378 KB/S</td>
<td>0.981 HR</td>
<td>1.33 x 10^3 MB</td>
</tr>
<tr>
<td>14</td>
<td>7.45 MB/S</td>
<td>0.701 HR</td>
<td>1.88 x 10^4 MB</td>
</tr>
<tr>
<td>15</td>
<td>6 KB/S</td>
<td>0.096 HR</td>
<td>2.07 MB</td>
</tr>
<tr>
<td>16</td>
<td>240 KB/S</td>
<td>0.064 HR</td>
<td>5.53 x 10^1 MB</td>
</tr>
<tr>
<td>19</td>
<td>1.6 KB/S</td>
<td>0.327 HR</td>
<td>1.88 MB</td>
</tr>
<tr>
<td>20</td>
<td>500 B/S</td>
<td>0.327 HR</td>
<td>0.589 MB</td>
</tr>
<tr>
<td>21</td>
<td>7 B/S</td>
<td>0.327 HR</td>
<td>0.008 MB</td>
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<tr>
<td>22</td>
<td>20 KB/S</td>
<td>0.064 HR</td>
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<td>23</td>
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<tr>
<td>25</td>
<td>3.6 KB/S</td>
<td>0.327 HR</td>
<td>4.24 MB</td>
</tr>
<tr>
<td>26</td>
<td>3.6 KB/S</td>
<td>0.327 HR</td>
<td>4.24 MB</td>
</tr>
<tr>
<td>27</td>
<td>1.12 KB/S</td>
<td>0.327 HR</td>
<td>1.32 MB</td>
</tr>
<tr>
<td>28</td>
<td>3 KB/S</td>
<td>0.327 HR</td>
<td>3.53 MB</td>
</tr>
<tr>
<td>29</td>
<td>200 B/S</td>
<td>1.135 HR</td>
<td>0.812 MB</td>
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</table>

TOTAL DATA TAKE: 1.280214 x 10^6 MB
<table>
<thead>
<tr>
<th>SENSOR</th>
<th>FILM</th>
<th>OPERATION RATE</th>
<th>FRAMES TAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35MM</td>
<td>1 FRAME/MINUTE</td>
<td>179</td>
</tr>
<tr>
<td>2</td>
<td>70MM</td>
<td>1 FRAME/10 SEC</td>
<td>107</td>
</tr>
<tr>
<td>3</td>
<td>11.5 x 128 CM</td>
<td>1 FRAME/10 SEC</td>
<td>419</td>
</tr>
<tr>
<td>4</td>
<td>24 x 48 CM</td>
<td>1 FRAME/TARGET</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>24 x 24 CM</td>
<td>2 FRAMES/TARGET</td>
<td>146</td>
</tr>
<tr>
<td>6</td>
<td>70MM</td>
<td>6 FRAMES/TARGET</td>
<td>240</td>
</tr>
<tr>
<td>7</td>
<td>24 x 24 CM</td>
<td>3 FRAMES/TARGET</td>
<td>24</td>
</tr>
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<td>9</td>
<td>16MM</td>
<td>2 FRAMES/TARGET</td>
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<td>10B</td>
<td>70MM</td>
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<td>TBD</td>
</tr>
<tr>
<td>11A</td>
<td>70MM</td>
<td>CONTINUOUSLY OVER SELECTED TARGETS</td>
<td>TBD</td>
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</tbody>
</table>
Figure 3-23, AESOP Is Used to Generate Experiment Scheduling and Requirement Summaries
Figure 3-24. Pollution Reference Mission Power Timeline for an Operational Period
two day coverage cycle. Since the mission is five days in length, the total data requirements may be obtained by multiplying the coverage cycle requirements by 2.5. The primary contributor to the $3.2 \times 10^{12}$ bit mission requirement is sensor 8, a 20-band multispectral scanner which has a data rate of 200 Mb/sec and is used 4.37 hours. The film requirements for the camera systems can easily be accommodated by state-of-the-art film magazines (i.e., the magazines will not have to be replaced). The two radars, sensors 10B and 11A might be a problem in terms of data storage on film, but because of later mission considerations (Section 5) this problem was not investigated.
4.0 BASELINE MISSION ANALYSIS

4.1 SENSOR/EXPERIMENT COMMONALITY

Figure 4-1 shows how 29 of the 33 MEO sensors are allocated to the nine experiments making up the Pollution Mission. The sensor package for each experiment (with the exception of M2, Stellar Occultation), consists of a varied grouping of sensors which are intended to satisfy the documented Level 1 experiment requirements. Three sensors (1, 2, and 32) find essentially universal use by the experiments, while 11 (38 percent) of the sensors are experiment-unique. Among the latter are nine that are unique to the Air Pollution experiment, one (the Synthetic Aperture Radar, 10) that is unique to the Water Pollution experiment, and one (the Star-Tracking Telescope, 18) that is both unique to, and the only sensor required for, the Stellar Occultation experiment.

Only the Stellar Occultation experiment requires a single sensor (the Star-Tracking Telescope); each of the other eight experiments require from seven to fourteen sensors, with the Air Pollution experiment having the largest complement of (as well as most of the experiment-unique) sensors.

As a class, the six camera systems find the widest use, with one-half or more (of the class) being used in all but the Meteorology experiments. In the multisensor Air Pollution experiment, the emphasis is on radiometers, interferometers, spectrometers, a polarimeter and a gas filter optical correlation sensor, with a pointable identification camera used to record the scene during data-gathering periods.
<table>
<thead>
<tr>
<th>NO.</th>
<th>SENSOR</th>
<th>WATER POLLUTION</th>
<th>STELLAR OCCULTATION</th>
<th>AIR POLLUTION</th>
<th>VOLCANIC ACTIVITY</th>
<th>EARTH GEODESIC &amp; GEOMAGNETIC PROCESSES</th>
<th>MOUNTAIN AREA</th>
<th>ARCTIC</th>
<th>LASER EMISSION</th>
<th>ENVIRONMENTAL PROJECT</th>
<th>NO. OF EXPERIMENTS USING SENSOR</th>
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<td>TRACKING TELESCOPE</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
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<td>2</td>
<td>POINTABLE IDENT CAMERA</td>
<td>X</td>
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<td>PAN CAMERA</td>
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<td>WIDE-ANGLE CAMERA</td>
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<tr>
<td>11</td>
<td>STAR TRACK TELESCOPE</td>
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<td></td>
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</tr>
<tr>
<td>12</td>
<td>LASER ALT/SCAT</td>
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<tr>
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<td>HIGH RES IR MS SCANNER</td>
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<tr>
<td>17</td>
<td>UV UPPER ATMOS SOUNDER</td>
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<td>VIS RADIATION POLARIMETER</td>
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<tr>
<td>19</td>
<td>AIR POL CORREL SPECT</td>
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<td>TIROS-N OPER MIR SOUNDER</td>
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**Figure 4-1.** MEO Sensor Usage in Pollution Mission
4.2 DATA HANDLING AND MANAGEMENT

4.2.1 Digital Data

Most of the instruments on the pollution reference mission obtain digital data. The primary data contributor is sensor number 8, a 20-band multispectral scanner. This data can be handled by on-board storage in tape recorders with capacities up to $10^{11}$ bits at rates as high as 200 Mb/s.

4.2.2 Film Data

The camera systems and radars store data on film. Conventional film magazines can accommodate the number of frames taken by the camera systems on the pollution reference mission.

The volume of film required for recording SAR data can be obtained by considering a state-of-the-art cathode ray tube (CRT) with a spot size of 25μ and sensor 11A, a dual polarized, three frequency radar with a ground resolution of 30 m. It is assumed that the film is coupled to the CRT by fiber optics. Six CRT's will be required. With a ground resolution of 30 m, one "A" scan will have to be generated for every 30 m of motion of the spacecraft. With a subsatellite velocity of 7 km/sec, 233 "A" scans will have to be produced every second. With a film packing density of 24 "A" scans/mm the film velocity will be 9.7 mm/sec. Assuming continuous coverage is desired over the Continental United States, ~300 minutes of data will be obtained in a five day mission. By multiplying this value by the film velocity, a film requirement of 174 m for each polarization and frequency combination is obtained. The remaining radar, sensor 10B is a single polarization, single frequency sensor with a spatial resolution of 30 m so it would require only one CRT and 174 m of film. Therefore, the film requirements appear to be easily met. The requirement for 7 CRTs may create a volume problem in the Sortie Lab.

4.2.3 Ground Station Visibility Times

On any given Shuttle Sortie earth observation mission there may be a requirement to transmit data to the ground. For example, if a tropical storm has developed into a hurricane off the coast of the United States there may be a requirement for observations (more detailed or sophisticated than would be normally available) using several of the Shuttle sensors.
These data would be used to enhance the storm warning and damage assessment capabilities of those agencies responsible for such activity. This information would be needed as soon as possible. Using the S-band ground link on the Orbiter, information could be relayed to the ground whenever the Orbiter was within the readout circle of a given data station.

To assess the potential data dump capability of the Manned Earth Observatory on a pollution mission, the Manned Space Flight Network (MSFN) was used in a computer simulation to determine the range of ground station visibility times that would occur. This was accomplished by using the RISET and CARTOG computer programs described in Section 3.2. The data handling capability of the Manned Earth Observatory during an on-call, potential disaster situation is discussed in Section 4.4.

The MSFN is a world-wide tracking and data acquisition system that was established by NASA to support manned spaceflight programs. It consists of land based stations, located around the world between the latitudes of approximately 40 degrees North and 40 degrees South, supplemented by one instrumentation ship. Table 4-1 lists the network stations and their geodetic coordinates. Figure 4-2 illustrates the geographic location and distribution of the stations. The Goddard Space Flight Center (GSFC) is included on the map because it is the MSFN Operations Center.

RISET was used to determine the ground station visibility time history for a two day coverage cycle of the 183 nautical miles, 48 degree pollution reference mission orbit. A CALCOMP plot of the visibility time history is shown in Figures 4-3 and 4-4. A summary of the results is displayed in Figure 4-5. The amount of time available for dumping data at any one station in one orbital revolution varies from one minute to six minutes (see Figure 4-5). Assuming an S-band transmission rate of 1 Mbps, 360 Mb can be dumped in six minutes to a ground station per revolution. If data obtained by sensor number 8 is to be dumped, there may be problems because of its exceptionally high data rate (in six minutes only 1.8 seconds worth of sensor 8 data could be dumped). Figure 4-5 shows that at least 20 minutes of ground link transmission time are available with the stations in the five day mission time period, in the five day mission time period.
### Table 4-1. MSFN Station Designators and Geodetic Coordinates

<table>
<thead>
<tr>
<th>Station</th>
<th>Station Designator</th>
<th>Latitude</th>
<th>Longitude</th>
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<td>345°40</td>
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<tr>
<td>Bermuda, U.K.</td>
<td>BDA</td>
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<td>295°20</td>
</tr>
<tr>
<td>Carnarvon, Australia</td>
<td>CRO</td>
<td>-24°53</td>
<td>113°43</td>
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<tr>
<td>Grand Canary Island, Spain</td>
<td>CYI</td>
<td>27°45</td>
<td>344°21</td>
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<td>Goldstone, California</td>
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<td>GWM</td>
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<td>HAW</td>
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<td>TAN</td>
<td>-19°00</td>
<td>47°18</td>
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Figure 4-2. Geographic Location of the MSFN Stations
Figure 4-4. Pollution Reference Mission  
Ground Station Visibility Times  
(Second Day of Two-Day Coverage Cycle)
A. ALL STATIONS (TOTAL MISSION)

B. PER STATION (TOTAL MISSION)

Figure 4-5. Ground Station Coverage Histograms
4.3 ROLE OF MAN

4.3.1 Introduction

Design studies of candidate earth observation experiments for the Shuttle Manned Earth Observatory have suggested an important role for man. The multi-sensor, multi-objective character of the candidate Shuttle-MEO missions, together with the special calibration and other requirements of particular experiments may, in fact, make man absolutely necessary. Optimum utilization of the many capacities of man will, however, require comprehensive consideration of the man/sensor interface system and a rigorous training program.

The functions to be performed by man have been examined in the somewhat constraining framework of the candidate Priority I Mission directed at pollution problems. The sensor complements are generally off-the-shelf and are therefore not specially designed to permit man to change instrument performance characteristics or to require special attention as other instruments may necessitate. Similarly, the Sortie Lab with pallet configuration is not designed for maximum access to the sensor packages and man's role may be limited in the area of sensor deployment.

Some commentators on the role of man for space earth observation programs have implied that man has exceptionally wideband data processing and control capabilities. We know of no evidence that man's input bandwidth is even comparable to current sensor standards and his communicative output capabilities which, when complemented by equipment to extend his visual characteristics and when interfaced with machine sensor controls, extend these capacities far beyond those of a machine data processing system.

In considering the role of man in these several modes we have drawn upon a body of literature generated over the past decade on the subject and have examined the described functions in the context of the individual candidate experiments and mission through use of scenarios, reference to similar manned space missions, and review of aircraft scientific experimentation. The following sections will seek to identify and weigh man's contribution to the candidate Shuttle - MEO Pollution
Mission and recommend the types of instruments and control interfaces to optimize that contribution.

4.3.2 The Roles of Man in a Manned Earth Observatory

(See Figure 4-6)

4.3.2.1 Pollution Mission — Role of Man's Evaluation

The candidate experiments comprising the Priority I Pollution Mission have been discussed in detail in Volume I of this study. The sensor systems and observational requirements of this mission are about as complex as are likely to be experienced in MEO missions. Manned interaction may be required simply to operate and select appropriate targets (predictable but not easily programmed for very high-resolution sensors). The specific functions for man discussed below represent a compilation based on our experiments and literature review.

4.3.2.2 High-Resolution Target Selection

Experience with the Apollo G/N tracking telescope has defined a need for an interface between the viewing telescope and the G/N computer of the spacecraft. Coarse pointing can then be accomplished in an automated mode with the scientific director providing the final target selection and image centering. A programmed instruction set with manual override could be used as the basis of the planned orbital parameters and target locations.

4.3.2.3 Documentation and Annotation

A characteristic problem with some of the early manned earth observation efforts was a lack of documentation of the photographs. Man as a scientific observer/experimenter should be charged with the task of assuring that the observations are appropriately documented. Man's primary role in this task will be to verbally note features that cannot be electronically or mechanically documented. Appropriate interfaces should be provided to permit accurate time (after day of launch and absolute) correlation with the sensor records.
## Functions vs. Experiments

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**Code:**
1 MAN ESSENTIAL  
2 MAN USEFUL  
3 NO ROLE FOR MAN

*Figure 4-6. Pollution Reference Mission Role of Man*
4.3.2.4 Priority Establishment and Coordination

Multiple experiments and sensors in association with many diverse targets will require a significant amount of emphasis on priority and coordination. Man can play a highly significant role in choosing among various targets to pick the most important. Man can play a major role in coordinating the ground teams and in coordinating the onboard experimental program.

4.3.2.5 Targets of Opportunity

Man plays a highly significant role as a part of his scientific observational tasks in taking advantage of targets of opportunity. It is important to note that "targets of opportunity" includes two classes of targets; those that generally can be predicted, such as a well-developed tropical storm, and those that cannot be predicted as, for example, the birth of an undersea volcano. In the former case, a program modification plan can be developed by ground control; in the latter case, the onboard scientific observer must act to record the event in as accurate and timely a manner as possible. Once the observational routine is completed, the ground controller must assess the impact on the mission.

4.3.2.6 Interpret and Generalize

To the extent that the onboard scientist can be aware of the phenomenon that he is observing, through its visual manifestations, he is in an optimum position to interpret what he sees. Even with a well-designed sensor control system, it is questionable that all associated training of the scientist/observer will be suitably recorded.

A most important element of the candidate experiments then is the interpretation of the perceptions of the scientist. These must be recorded on the spot and automatically correlated to the sensor records.

The degree of interpretation that can be accomplished is controlled by the degree to which scientist/observer awareness can be engineered into the experimental program and by the relevant knowledge and associated training of the scientist/observer. Individuals vary widely in their perceptiveness, independent of knowledge and training. Because
of this, emphasis should be given to scientist/observer selection where some method of testing individual perceptiveness can be employed.

Generalization becomes possible after a number of repetitions of the experimental procedure. It may cover evaluations of the equipment, discovery of persistent or repetitious features in the observed data, and will inevitably include a succinct evaluation of the overall performance of the experiment.

4.3.2.7 **Image Signature Analysis**

This activity will in one manner or another, be a continuing task for the scientist/observer. Its performance is implicit in many of the prior functions. Specifically, the task involves classification of a phenomena or event based on current data. The classification rules will be either deterministic or probabilistic, but they are generally unknown prior to analysis. This function is experiment oriented, and as stated earlier, is an implicit part of other functions. The function may be thought of as an integration of observations.

Some specific signature analysis activities will be performed by man using onboard processors and displays. The skill requirements are of a high order.

The communications system, controls and displays, must be carefully defined to permit optimum involvement of man in the system. For example, means should be available to visually or audibly cue the scientist/observer on the basis of preprocessed target signatures. These cuing signals should be made integral with a tracking telescope viewing the control station.

4.3.2.8 **Improvisation**

In some cases, experimental procedures can be left sufficiently flexible to permit, or perhaps demand, on-the-spot improvisation by the scientist/observer. This may involve the use of alternate procedures or equipment in the event of malfunctions of the primary procedures or equipment.
4.3.2.9 Instrument Experimentation and Repair

One of the more widely touted uses for man in space for earth observation is his potential capability of manipulating instruments for test and development. In the candidate sensor list nearly all of the sensors are off-the-shelf. None are designed to permit ready alteration. Specifically developed modular sensors and equipments would vastly improve man's ability to perform useful and effective experimentation in space.

4.3.2.10 Calibration

A prime activity for man on the Shuttle MEO may involve instrument calibration activities. For example, one sensor requires that man calibrate it by varying the timing of a detector gate until he locates the ocean surface so that an automated scan can provide soundings to various depths below the surface. Another activity of man might be in the deployment of a "standard" gray card for in-space calibration of color film cameras. Side looking radar systems may require signal level monitors and/or calibration over salt lakes and other uniform surfaces.

Man can make a significant contribution to instrument calibration efforts. He will need the appropriate displays to assist the calibration efforts.

4.3.2.11 Processor and Display Test and Evaluation

In the early Shuttle MEO flights man will make a significant contribution in the area of the onboard processor and its associated displays for scientific applications. A variety of routines should be available to permit man to process the electronic sensory data and generate test displays. The test displays should be drawn from real-data as obtained from the Skylab program so as to permit comparisons with the real-time data collected in performance of various MEO experiments. Coordination with ground experiment controllers will be required to provide verification for the onboard test in some instances and provide revised or updated processor or display routines in others.
4.3.2.12 Sensor Deployment

Sensor deployment is an area which has been considered by many commentators to be one where man can play a major role. This assumption is certainly true if the Sortie Lab is designed for these types of activities. The tentative plan to place most of the instruments on the pallet will generally constrain any substantial sensor deployment activities. If air locks can be installed in the Sortie Lab man can be used to load and unload film, change filters, change focal lengths, etc. The desired level of functional participation for man should therefore be a significant design consideration for the MEO Sortie Lab. Significant improvements in experiment accomplishment could be made if man's role were optimized by the Lab design.

4.3.2.13 Data Packaging

This role for man is very straightforward but extremely important. Photographic film must be environmentally controlled throughout its entire use cycle in order to attain high quality end results. Procedures should be established for maintaining strict handling and storage controls, and man's role will be to implement and maintain the integrity of these controls. Magnetic tapes also require reasonable packaging and handling and the scientist/observer can play a significant role in assuring the integrity of the packaging of the data.

4.3.2.14 Report Preparation

Since the scientist/observer will often be expected to be either the principal investigator or coinvestigator, it is clear that report preparation will be a manned activity both in the MEO Lab and on the ground after recovery. The MEO Lab should be provided with tools and space for report initiation.

4.3.2.15 Communication

One of the prime roles for man in Shuttle - MEO will be as a communicator. The various types of communicator roles will range from the required mission status updates to coordination with ground observer teams to disaster warnings. Since time may be of the
essence during the Sortie mission, careful consideration should be directed to means for compressing or coding the communicated data, e.g., by design of appropriate languages. Equipment should be provided to permit emergency transmission direct to any point on earth.

Communication in its various forms is an important function to be performed by man in Shuttle MEO. Procedures, equipment, language, etc. should be carefully reviewed.

How do these roles apply to the candidate Priority I Pollution Mission? Figure 4-6 presents a summary matrix which offers an estimate of man's role on the basis of a three-level code. Notice that man is essential in all of the candidate experiments. Obviously, this is not an unexpected result; however, the performance of man's essential role depends on the provision for various tools and certain design considerations as mentioned in each of the functional discussions.

4.3.3 The Optimum Use of Man in Shuttle MEO

We consider two possible extremes of experiment philosophy, viz., (a) We put a man with a camera, some technical background, intellectual curiosity, and a keen "eyeball" in Shuttle MEO, and instruct him to observe, or (b) we put man and a large number of automated sensors at opposite ends of the spacecraft, leaving man the function of monitoring the orientation of the spacecraft, perhaps turning sensors on and off, and supervising data recovery.

The first example (a) is unaided man; the second (b) can easily be misemployed man. The concept inherent in our thinking for Shuttle MEO is that the presence of man on the mission drives the way that the experiments will be conducted. When we have a group of sensors at one end of the Shuttle and man at the other end, we must provide the means to permit man to control those instruments. Certainly automated instruments will and should fly in Shuttle MEO payloads, but the primary consideration should be "is man going to be asked to make a decision on the targets for which this sensor is to be used?" If the answer is yes, and the sensor is gimbaled, means should be provided to permit man to direct the sensor.
In summary, controls and displays should be provided on Shuttle MEO to assure optimum participation in those functions listed in the previous section. If it is difficult to do this for a single sensor, then it may evolve that the sensor in question would be flown on an unmanned satellite or as a sensor test experiment on Shuttle in such a way as to offer as little interference as possible to the man-directed sensors.

4.3.4 Conclusions

Man has an important role in the Shuttle MEO Sortie Lab. Full realization of that role depends on the appreciation by the experiment designers of:

1) The performance capabilities of man in the Sortie Lab
2) The ways in which man's participation can enhance the objectives of the experiments
3) The ways that man's interest and motivation can be stimulated, and
4) The common tools, i.e., displays, viewing telescopes, processors, etc., that will be available on the Shuttle Lab.

A more in-depth look into the role of man, in relation to the design of MEO, is presented in Volume III, Section 6.0.

4.4 SHUTTLE EARTH OBSERVATION DATA HANDLING AND CONTINGENCY PLANS

The Shuttle-manned earth observatory will play a key role in research in operations which are directed towards evaluation of the resources of earth. A less publicized, but no less important, role for the Shuttle observatory would be on-call disaster assessment. Review of Shuttle MEO capabilities to perform effectively in each of the preceding roles requires consideration of the overall data handling mission/target/data interrelationships. The following sections will present a brief review of the data handling considerations for Shuttle and will examine those data handling considerations in terms of a real on-call, potential disaster situation.
4.4.1 Data Handling Mission/Target/Data Interrelationships

Figure 4-7 presents a general diagram of the overall interrelationships between types of missions, targets, and data. The missions can generally be separated into research and development types and operational types. Targets can be generally categorized as preprogrammed targets, around which the mission is planned, and targets of opportunity. Targets of opportunity can be subdivided into two classes; those that can be predicted or programmed on the basis of information gathered during the Shuttle mission, information gathered from various unmanned satellite platforms, or information transmitted by observers onboard ship or on land at any point on the globe, and those which are essentially unpredictable, such as might be observed by the astronaut during the performance of his primary mission role. In the former category of opportunity targets, the options for coverage can be assessed by ground controllers and appropriate adjustments made in mission time-lines to accommodate the proposed on-call diversion from the planned mission objectives. In the latter case, the decision to divert from the planned mission must necessarily be initiated by the scientist/observer with subsequent mission accounting and time-line update being delegated to the ground controller.

The general types of data that will be acquired during the Shuttle mission are outlined in Figure 4-6 as digital film and voice. The on-call assessment role for Shuttle will probably make use of each of these data types; however, in the case of a potential disaster assessment, emphasis will be directed to those types of data that can be transmitted to the ground for subsequent evaluation and application to the disaster situation. Currently planned sensor data handling systems for MEO, as defined by the requirements of the pollution mission, are defined in Volume III, Section 7.0.

4.4.2 Data Handling for a Forecastable Target of Opportunity

Figure 4-8 outlines the general situation; the scenario — the Shuttle MEO pollution mission is entering day six of a seven-day mission. A tropical storm, which has been tracked over several days, is developing into a hurricane off the southeastern coast of the United States — the
Figure 4-7. Data Handling Mission/Target/Data Inter-Relationships
requirement on Shuttle MEO: get a detailed evaluation of the developing storm as soon as possible.

SCENARIO:

- MISSION — POLLUTION
- TIME — BEGINNING OF DAY 6
- SITUATION — TROPICAL STORM IS DEVELOPING INTO A HURRICANE OFF THE SOUTH EASTERN COAST OF THE UNITED STATES. A DETAILED EVALUATION IS NEEDED AS SOON AS POSSIBLE.

Figure 4-8. Data Handling of a Forecastable Target of Opportunity

The Shuttle MEO pollution mission has a substantial number of sensors onboard. Figure 4-9 indicates which sensors can be appropriately directed toward the storm assessment role and the observables for which they are most suited. Figure 4-10 provides an overview of the appropriate Shuttle passes providing the on-call disaster assessment coverage and the distribution of ground readout station coverage available for direct transmission. Very important information could be derived about the future course of the hurricane and changes in intensity could be inferred if it were possible to transmit data on visual properties, cloud liquid water contents, sea surface temperatures, and lightning distributions during the time available on revolutions 1, 6 and 16, all providing a readout to either Corpus Christi, Texas, Cape Kennedy, Florida, or Bermuda (see Figure 4-11).
### Figure 4-9. Pollution Mission Instruments Used to Monitor Hurricane

<table>
<thead>
<tr>
<th>Desired Observables</th>
<th>Cloud Visual and Optical Prop</th>
<th>Cloud Top Temp/Pressure</th>
<th>Cloud Liquid Water Content/Drop Size</th>
<th>Ice vs. Water Cloud</th>
<th>Sea Surface Temp</th>
<th>Sea State</th>
<th>Precipitation</th>
<th>Vertical Temp Profile</th>
<th>Lightning</th>
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<tbody>
<tr>
<td>Tracking Telescope</td>
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<td>Wide Angle Framing Camera</td>
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<td>Visible Radiation Polarimeter</td>
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<td>TIROS N ADV Very High Res Radiometer</td>
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<td>Wide Angle Viewer</td>
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</table>

(1) From Sun Glitter
Figure 4-10. MEO Readout for Typical Day
## Data Dump for Disaster Warning and Assessment

<table>
<thead>
<tr>
<th>SENSOR</th>
<th>REV 1</th>
<th>REV 6</th>
<th>REV 16</th>
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<td>32</td>
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</table>

**Transmittable Data**

**Data Dump Time (Seconds) (Assumes 4 MB/S Transmission Rate)**

- **Required**
  - 61.3
  - 60.3
  - 61.1

- **Available**
  - 347.4 (MIL + BDA)
  - 191.4 (MIL)
  - 489 (MIL + BDA)

Figure 4-11. Data Dump for Disaster Warning and Assessment
4.4.3 Summary

The Shuttle-manned earth observatory, as configured with sensors and communications equipment for a pollution mission, is fully capable of providing on-call coverage for a range of contingency situations. In the specific case of the hurricane threatening the Florida coast, more than ample data could be provided to ground-based evaluators. The on-call capabilities for disaster assessment and short-term phenomena coverage outside of the continental United States has not yet been evaluated and may introduce problems which would require reassessment of the generally positive conclusions of this study. The primary consideration appears to be the possible need to transmit data through a tracking and data relay satellite into a location where appropriate analysis and evaluation can occur.
4.5 SHUTTLE'S ROLE IN MULTI-STAGE SAMPLING OF THE MARINE ENVIRONMENT

The data gathering capabilities of spaceborne or airborne remote sensors are creating increased interest in the possibilities of developing up to date information management systems for marine and terrestrial environments. Bright as the prospects appear to be, for terrestrial resources where the time constant of change in the objects to be mapped is large, the dynamic marine environment requires a careful review of approaches to be attempted.

Synoptic data gathering procedures are essential to survey of the marine environment. The problems introduced by the dynamic nature of the oceans lie in the necessity for temporal coordination of the data acquisition activities. The advent of the Shuttle spacecraft in the early 1980's may permit the application of techniques of multi-stage sampling from a single space platform. In the marine environment, decision processes and subsequent actions relating to a given multi-stage survey must be concerned with the dynamics of the features to be investigated. A shuttleborne, multi-stage sampling system could provide the synopticity necessary for effective survey of many of the phenomena of interest.

4.5.1 Multi-Stage Sampling Options with Shuttle

Multi-stage sampling is a process whereby subsequent samples for a resource survey are drawn as the basis of prior knowledge. In remote sensing the prior knowledge is usually obtained with observing systems having spatial or spectral resolution and/or coverage capabilities which are inferior to those used in subsequent stages. The Shuttle Manned Earth Observatory offers a capability to collect both moderate and high spatial and spectral resolution data. The data handling capability for simultaneous collection of moderate and high resolution (spatial and spectral) data for large geographic areas is not available, thus it is necessary to define an effective sampling strategy which can be guided by an on-board computer system on the basis of the real time information acquired with the moderate resolution (spatial and spectral) sensors.

An effective multi-stage sampling strategy which considers man's participation in an experimental role could be directed toward some really fundamental questions of "indeterminacy." Specific multi-stage
strategies might be developed to delve into the complex spatial, spectral and temporal elements that may comprise a complex imaged scene. Operational multi-stage strategies might be developed for specific resource surveys, such as forest inventory, agricultural inventory, etc.

The following discussion of a marine environment application of multi-stage sampling provides an example of a complex problem addressable from the Manned Earth Observatory.

4.5.2 A Marine Environment Application of Shuttleborne Multi-Stage Sampling

The world's oceans offer a tremendous potential for high quality animal protein for both direct human consumption and as a supplement to animal feeds. The ocean, however, is not uniformly productive; nearly 70 percent of the total harvestable proteins are produced over less than 10 percent of the total surface area of the ocean. Many of the primary production areas are geographically well located but they are only poorly understood in terms of their spatial distributions and their temporal variability. Some areas of potential high productivity, in the equatorial regions in particular, are not well known.

The time constants of the physical and biological processes which drive areas of high production are reasonably well-suited to a sampling rationale utilizing observations from unmanned spacecraft. Sampling periods shorter than phenomena duration will provide first order selection criteria for use in a multi-stage sampling design. Following review of the unmanned satellite observations, sample areas can be defined and subsampling units indicated on a grid on which the Shuttle suborbital track has been defined. Some level of stratification can be considered if there is sufficient background knowledge on the general variability in productivity as defined by the low resolution unmanned satellite image. Regardless of how the unmanned observations are partitioned, the subsequent sub-units should be of a size that is readily associated with the fields of view of the sampling sensors on the Shuttle. The primary problem which attends the marine survey case and is generally not applicable to the terrestrial phenomena situation is the necessity to differentiate between the spectral modifications introduced into the backwelling spectrum by the presence of living and non-living scatterers. Living, chlorophyll-containing microscopic algae form the first trophic level, or basic food
source, for nearly all surface pelagic commercial species. The non-
living particulate matter in the water can produce similar signatures that
may or may not relate to the distribution of chlorophyll. Thus, we are
faced with the necessity for multi-stage sampling of spectral characteris-
tics as well as spatial characteristics. In the current experimental programs,
directly related to commercial fisheries, aircraft flying at mid-altitude
carrying multi-spectral scanners and cameras have been used to further
delineate the spectrally significant areas from the spectrally insignificant
areas within the spatial distributions mapped from the ERTS-1 satellite.
The Shuttle era marine resource survey system could both compliment
such aircraft flights in regions where they can be readily deployed and
supplement such aircraft in those areas, and at those times, when their
deployment would be logistically difficult. Thus, the shuttleborne marine
resource survey system could fulfill several roles presently requiring
multiple platforms. Moderate resolution, moderate scale coverage could
be utilized from Shuttle to provide stratifications of the spatial distributions
of those signatures associated with living and those associated with non-
living scatterers. High resolution, large scale photography, covering
approximately six nautical miles at nadir, could provide a final detailed
delineation of the actual areas of highest productivity, if associated
with high spectral resolution data from a multispectral scanner.

4.5.3 Summary

A shuttleborne marine resource survey system in the 1980's is well
within the feasible state of the art. Implementation of such a system,
both for an overall survey and for deployment of surface vessels for either
research purposes or harvesting purposes, will require:

- The development of improved techniques for extracting
  more reliable information on the marine resource from
  spaceborne remotely-sensed data.

- Development of effective sampling strategies which are
  directed in real time by an onboard computer system.

- Development of predictive models to translate chlorophyll
  information to fishery production information.

Information gathered by a shuttleborne resource survey system
could provide the data necessary to establish reliable, versatile resource
information system applicable to large, global ocean areas and useful
within a marine resource information system.
5.0 LOW-COST MISSIONS

The 29 sensor pollution reference mission discussed in Sections 3.0 and 4.0 is a sophisticated, complex and costly mission which taxes the capabilities of the Shuttle. As a design driver it showed what the mission requirements would be for a most ambitious mission which attempted to satisfy all of the experiment requirements. After re-evaluating this mission, several questions arose. Since AESOP initially required experiment prioritization, why not reduce the mission to the first priority experiments? Are all 29 sensors equally important or do some obtain correlative and supplementary data? These questions led to the development of a "Low-Cost" definition rationale which, when applied to the pollution reference mission, reduced its cost and complexity and resulted in a low-cost pollution reference mission which is typical of early Shuttle Sortie missions. Because the low-cost mission is a reduced version of the initial mission, the initial mission is referred to as the "Baseline" mission. This terminology is carried through the remaining report volumes.

In this section, a tentative low-cost definition rationale will be described and applied to the baseline pollution reference mission. The low-cost and baseline versions of the pollution reference mission will be compared in terms of design in Volume III and in terms of costs in Volume IV. The first portion of the rationale is also applied to the other reference missions.

5.1 TENTATIVE LOW-COST DEFINITION RATIONALE

An overview of the definition rationale is shown in Figure 5-1. The three level experiment prioritization is identical to the one used to generate an input to AESOP (see Section 3.2.3.3). The experiment prioritization within each of the nine reference missions is shown in Table 5-1. Only the first priority experiments were considered in the low-cost mission.

The experiment sensors were prioritized into three levels:

- Mandatory — Data or use of instrument mandatory for execution of experiment.
- Valuable — Data is important for the execution of the experiment.
- Useful — Data of value, but not crucial for the execution of the experiment.
Figure 5-1. Low-Cost Mission Definition Rationale
Table 5-1. Experiment Prioritization by Reference Mission

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<th>Pollution</th>
<th>Envi Impact</th>
<th>Ocean/Met</th>
<th>Spring</th>
<th>Summer</th>
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<th>Winter</th>
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The sensor priorities for each of the Level 1 experiments are shown in Tables 5-2 and 5-3.

The developmental status of the sensors which have been identified as candidates for the Baseline Pollution mission is summarized in Tables 5-4 and 5-5. Of the 29 sensors, two have been proven in space flight, 14 have been partially developed, primarily under the Advanced Applications Flight Experiment (AAFE) program, and development of the remaining 13 remains to be initiated.

With respect to the seven air pollution sensors and the laser altimeter/scatterometer, the technical feasibility is questionable and supporting research and technology is required. All of the seven proposed air pollution sensors have been partially developed, primarily under the AAFE program. However, in all cases additional work is required to demonstrate the feasibility of obtaining the desired measurements of atmospheric constituents or pollutants from orbit by demonstration in aircraft, balloon, or Small Applications Technology Satellite test vehicles. The feasibility of using a laser to profile the depth of plankton in ocean water remains to be proved and the hardware has to be developed.

Sensor costs were obtained for the following:

- Supporting Research and Technology (SR&T)
- Design, Development, Test and Engineering (DDT&E)
- Fabrication of flight units and flight support
- Data analysis and publication.

A summary of the total sensor costs is shown in Tables 5-2 and 5-3.

Several of the sensors previously identified were second generation instruments (i.e., more sophisticated or modified versions of instruments which were currently available) or were similar to other instruments currently under development. As a result, the available instruments as well as those currently being developed were potential substitutes. Before a substitution could be made, the effect of a reduced or slightly different capability on the satisfaction of experiment objectives would have to be evaluated. In this study, possible substitute sensors were identified (see Table 5-6), but they were not used in defining a low-cost
## SENSOR PRIORITIZATION

1 = MANDATORY  
2 = VALUABLE  
3 = USEFUL

### FUNDING REQUIREMENT (R.O.M.) ($K)

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</table>

- **O1**: REGIONAL WATER POLLUTION EXPERIMENT (S.F. Bay)
- **O2**: SEA ICE MAPPING
- **O3**: PLANKTON PROFILING/COASTAL BATHYMETRY MEASUREMENTS
- **O4**: UPWELLING AREA MAPPING
- **O5**: OCEAN WIND AND WAVE EXPERIMENT
- **O6**: SUN GLITTER/MOON GLITTER MEASUREMENTS

- **M1**: NOCTILUCENT CLOUD PATROL
- **M2**: STELLAR OCCULTATION TO DETERMINE ATMOSPHERIC DENSITY
- **M3**: GLOBAL THUNDERSTORM AND LIGHTNING ACTIVITY
- **M4**: AIR POLLUTION MONITORING
- **M5**: WEATHER MODIFICATION EXPERIMENTS - TROPICAL STORMS
- **M6**: ICE ON THE SOUTHERN OCEAN

- **A1**: INTERNATIONAL AGRICULTURAL EXPERIMENTATION STATION MANAGEMENT PROGRAM
- **A2**: MULTISTAGE SAMPLING OF VEGETATION RESOURCES
- **A3**: WILDLIFE - ECOLOGY STUDIES
- **A4**: WINTER DAMAGE ASSESSMENT IN FOREST LAND

- **G1**: RAPID GEOLGIC RECONNAISSANCE MAPPING
- **G2**: COASTAL GEOLGIC AND GEOMORPHIC PROCESSES
- **G3**: REDUCED GRAVITY EXPERIMENTS/Demonstrations in Geology
- **G4**: GEOLGIC AND TOPOGRAPHIC MAPPING OF MOUNTAINOUS AREAS OF THE WORLD

- **H1**: GROUND WATER DISCHARGE AND MAPPING
- **H2**: MAPPING GROUND STATE - FROZEN OR NOT
- **H3**: SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT
- **H4**: SNOW AND ICE MONITORING STUDY
- **H5**: INTERNATIONAL SEASONAL STANDING WATER SURVEY

- **E1**: MONITORING EFFECT OF CHANGING LAND USE PATTERNS ET C.
- **E2**: LAKE EUTROPHICATION, ASSESSMENT OF MAN'S ROLE
- **E3**: WATER USE PATTERN - IRRIGATION

- **O7**: ORTHOGRAPHIC MAP CONSTRUCTION FOR DEVELOPING COUNTRIES
- **O8**: INTERNATIONAL DEVELOPMENT PROJECT PRE-FEASIBILITY ANALYSIS
- **O9**: INTERNATIONAL METROPOLITAN AREA BIENNIAL UPDATE PROGRAM
<table>
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<tr>
<th>Sensor</th>
<th>Description</th>
<th>Frame</th>
<th>Resolution</th>
<th>Coverage</th>
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<td><strong>Pointable Identification Camera</strong></td>
<td>70 mm film, 2.5 cm, 125 km (75 n.m.) coverage, 20 m resolution</td>
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<tr>
<td><strong>Photonic Camera</strong></td>
<td>17 cm, 0.5 in, 60 cm, (24 in.) f/1, 5 m resolution</td>
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<td><strong>Multispectral Camera System</strong></td>
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<td>Ocean Color Measurement</td>
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## SENSOR PRIORITIZATION

1 = MANDATORY  
2 = VALUABLE  
3 = USEFUL

### SENSOR

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### FUNDING REQUIREMENT (R.O.M.) ($K)

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Table 5-3: Sensor Prioritization by Experiment and Sensor Funding Requirements (R.O.M.)
Table 5-4. Development Status—Experiment Sensors

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<th>PARTIALLY DEVELOPED</th>
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<td>VISIBLE IMAGING SPECTROMETER</td>
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<td>TRW (AAFE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(WATER POLLUTION)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td>HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER</td>
<td>TRW (AAFE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>IMAGING IR RADIATORS</td>
<td>IR MULTISPECTRAL MECHANICAL SCANNER</td>
<td>TRW CONCEPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(WATER POLLUTION)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>HIGH RESOLUTION IR MULTISPECTRAL SCANNER</td>
<td>TRW CONCEPT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>STAR TRACKER</td>
<td>STAR TRACKING TELESCOPE</td>
<td>UNIV MICH CONCEPT</td>
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<td></td>
</tr>
<tr>
<td>20</td>
<td>VISIBLE RADIATION POLARIMETER</td>
<td>UCL (AAFE)</td>
<td></td>
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</tr>
<tr>
<td>19</td>
<td>UV UPPER ATMOSPHERE SOUNDER</td>
<td>UNIV OF COLO (AAFE)</td>
<td></td>
<td></td>
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<tr>
<td>26</td>
<td>ADVANCED LIMB RADIANCE INVERSION RADIOMETER</td>
<td>NCAR (AAFE)</td>
<td></td>
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<td>23</td>
<td>CARBON MONOXIDE POLLUTION</td>
<td>EXPERIMENT</td>
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<tr>
<td>21</td>
<td>AIR POLLUTION SENSORS</td>
<td>AIR POLLUTION CORRELATION SPECTROMETER</td>
<td>BARRINGER RESEARCH</td>
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<td></td>
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<tr>
<td>22</td>
<td>HIGH SPEED INTERFEROMETER</td>
<td></td>
<td>JPL (AAFE &amp; OMSF)</td>
<td></td>
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</tr>
<tr>
<td>25</td>
<td>REMOTE GAS FILTER CORRELATION ANALYZER</td>
<td>SCIENCE APPLIC (AAFE)</td>
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<tr>
<td>27</td>
<td>IR RADIOMETERS</td>
<td>TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER</td>
<td>ITT (CONTRACT INITIATED)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(CORRELATIVE DATA - AIR POLLUTION)</td>
<td></td>
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<tr>
<td>28</td>
<td>TIROS-N OPERATIONAL VERTICAL SOUNDER</td>
<td>UNDER STUDY (NOAA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.</td>
<td>SENSOR</td>
<td>ALTERNATE SENSOR</td>
<td>COMMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------</td>
<td>------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>TRACKING TELESCOPE</td>
<td>NONE</td>
<td>USED FOR HIGH RESOLUTION TELEPHOTO SIGHTINGS BY ASTRONAUT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>POINTABLE IDENTIFICATION CAMERA</td>
<td>SKYLAB S-190 MULTISPECTRAL PHOTOGRAPHIC</td>
<td>POINTABLE IDENTIFICATION CAMERA USES TWO CAMERAS. S-190 HAS SIX CAMERAS ON COMMON MOUNT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>70 mm film</td>
<td>FACILITY (WITH 2-AXIS GIMBALS ADDED)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PANORAMIC CAMERA (5 in.film)</td>
<td>NONE</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>WIDE ANGLE FRAMING CAMERA</td>
<td>NONE</td>
<td>USED IN CONJUNCTION WITH PANORAMIC CAMERA FOR CARTOGRAPHIC MAPPING</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 x 48 cm. (9 x 18 in.) film</td>
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</tr>
<tr>
<td>5</td>
<td>MULTISPECTRAL CAMERA SYSTEM</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>24 x 24 cm. (9 x 9 in.) film</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>HIGH RESOLUTION MULTISPECTRAL SYSTEM</td>
<td>SKYLAB S-190 MULTISPECTRAL PHOTOGRAPHIC</td>
<td>IF S-190 USED, MUST CHANGE OPTICS FROM WIDE ANGLE TO TELEPHOTO.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(70 mm film)</td>
<td>FACILITY (WITH 2-AXIS GIMBAL ADDED)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7</td>
<td>MULTISPECTRAL CAMERA SYSTEM</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 x 24 cm. (9 x 9 in.) film</td>
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<td></td>
<td></td>
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<tr>
<td>8</td>
<td>HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER</td>
<td>SKYLAB S-192 MULTISPECTRAL SCANNER WITH 2-AXIS GIMBAL ADDED</td>
<td>S-192 HAS ONLY 13 SPECTRAL BANDS. P.I. DESIRES 20 SPECTRAL BANDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30/60 m resolution (20 Spectral Bands)</td>
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<td></td>
</tr>
<tr>
<td>9</td>
<td>LWIR SPECTROMETER</td>
<td>SKYLAB S-191 INFRARED SPECTROMETER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.2 - 15.5, 0.4 - 2.4μ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10A</td>
<td>WIDEBAND SYNTHETIC APERTURE RADAR</td>
<td>DUAL FREQUENCY SYNTHETIC APERTURE RADAR (X- AND L-BAND, 3 and 26 cm.)</td>
<td>PROPOSED BY JPL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(WBSAR) (Wide Coverage, Low Resolution Mode)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10B</td>
<td>WIDEBAND SYNTHETIC APERTURE RADAR</td>
<td>SAME AS 10A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(WBSAR) (Medium Coverage, High Resolution Mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11A</td>
<td>MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWSAR)</td>
<td>SAME AS 10A</td>
<td>MFWBSAR FREQUENCIES ARE 3, 5.5, 10 GHz. JPL DUAL FREQUENCY SAR FREQUENCIES ARE 1.15 AND 10 GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(MFWSAR) (Medium Coverage, Low Resolution Mode)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>11B</td>
<td>MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWSAR)</td>
<td>SAME AS 10A</td>
<td>SAME AS ABOVE (11A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(MFWSAR) (Narrow Coverage, High Resolution Mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>LASER ALTIMETER/SCATTEROMETER</td>
<td>NASA-MSFC LED-PUMPED Nd:YAG LASER (AAFE 1971) IS A POSSIBILITY</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13</td>
<td>VISIBLE Imaging SPECTROMETER</td>
<td>OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC)</td>
<td>EOS OSS IS IN R&amp;D STAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>IR MULTISPECTRAL MECHANICAL SCANNER</td>
<td>EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Ocean Surface Temperature Measurement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>HIGH RESOLUTION VISIBLE SPECTROMETER</td>
<td>OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC) WITH TELEPHOTO LENS</td>
<td>EOS OSS IS IN R&amp;D STAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Ocean Surface Temperature Measurement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>HIGH RESOLUTION IR MULTISPECTRAL SCANNER (Ocean Surface Temperature Measurement)</td>
<td>EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER MODIFIED FOR NARROW FOV (TELEPHOTO OPTICS, POINTABLE)</td>
<td>USE OF EOS STIR WILL REQUIRE MAJOR REDESIGN FOR NARROW FOV.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>GLITTER FRAMING CAMERA</td>
<td>WESTINGHOUSE SEC VIDICON CAMERA FROM APOLLO PROGRAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>STAR TRACKING TELESCOPE</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>UV UPPER ATMOSPHERE SOUNDER (UVUAS)</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution Mode</td>
<td>Description</td>
<td>Notes</td>
<td></td>
<td></td>
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<td>----------------</td>
<td>-------------</td>
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<td></td>
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<tr>
<td>11B MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWSAR)</td>
<td>Narrow Coverage, High Resolution Mode</td>
<td>SAME AS 10A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 LASER ALTIMETER/SCATTEROMETER</td>
<td>NASA-MSFC LED-PUMPED Nd:YAG LASER</td>
<td>SAME AS ABOVE (11A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 VISIBLE IMAGING SPECTROMETER</td>
<td>OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC)</td>
<td>EOS OSS IS IN R&amp;D STAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 IR MULTISPECTRAL MECHANICAL SCANNER (Ocean Surface Temperature Measurement)</td>
<td>EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER</td>
<td>OCEANIC SCANNING SPECTROPHOTOMETER FOR EOS (WARREN HOVIS, NASA-GSFC) WITH TELEPHOTO LENS</td>
<td>EOS OSS IS IN R&amp;D STAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 HIGH RESOLUTION IR MULTISPECTRAL SCANNER (Ocean Surface Temperature Measurement)</td>
<td>EOS SEA SURFACE TEMPERATURE IMAGING RADIOMETER MODIFIED FOR NARROW FOV (TELEPHOTO OPTICS, POINTABLE)</td>
<td>USE OF EOS SSTIR WILL REQUIRE MAJOR REDESIGN FOR NARROW FOV.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 GLITTER FRAMING CAMERA</td>
<td>WESTINGHOUSE SEC VIDICON CAMERA FROM APOLLO PROGRAM</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 STAR TRACKING TELESCOPE</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 UV-visible ATMOSPHERE SOUNDER (UVUAS)</td>
<td>NONE</td>
<td>--</td>
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<tr>
<td>20 VISIBLE RADIATION POLARIMETER (VRP)</td>
<td>NONE</td>
<td>--</td>
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<tr>
<td>21 AIR POLLUTION CORRELATION SPECTROMETER</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 HIGH SPEED INTERFEROMETER (HSI)</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 CLOUD PHYSICS RADIOMETER (CPR)</td>
<td>NONE</td>
<td>--</td>
<td></td>
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<td></td>
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<tr>
<td>25 REMOTE GAS FILTER CORRELATOR ANALYZER (RGFCA)</td>
<td>NONE</td>
<td>--</td>
<td></td>
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</tr>
<tr>
<td>26 ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR)</td>
<td>NONE</td>
<td>--</td>
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<td></td>
</tr>
<tr>
<td>27 TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 PASSIVE MICROWAVE RADIOMETER (PMMR) (5 BANDS, 4.99 - 37 GHz)</td>
<td>NIMBUS E (19.35 GHz) -- AEROJET CORP., NIMBUS F (37.5 GHz) -- AEROJET CORP., NIMBUS E MICROWAVE SOUNDER (JPL) (5 Bands, 22-59 GHz)</td>
<td>USE OF ALTERNATE SENSORS WILL NOT SATISFY SCIENTIFIC OBJECTIVES OF PMMR DUE TO USE OF FEWER OR DIFFERENT FREQUENCY BANDS.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 MICROWAVE RADIOMETER/SCATTEROMETER (37 GHz)</td>
<td>SHUTTLE IMAGING MICROWAVE SYSTEM NASA-MSC CONTRACT NAS7-100 RD4-219 to JPL</td>
<td>PASSIVE SYSTEM ONLY. REQUIRES DEPLOYMENT OF 30 FT. PARABOLIC ANTENNA. SIX BANDS (0.3 - 94 GHz). CURRENTLY IN DEFINITION PHASE.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 SFERICS RECEIVER (5 - 20, 300, 610 MHz)</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER</td>
<td>NONE</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 DATA COLLECTION SYSTEM</td>
<td>NONE</td>
<td>--</td>
<td></td>
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</tr>
</tbody>
</table>
pollution reference mission. In the next phase of the study when the definition rationale is finalized, the substitute sensors will be given serious consideration.

5.2 LOW-COST POLLUTION MISSION

5.2.1 Application of Low-Cost Definition Rationale

The experiment prioritization resulted in the groups shown in Table 5-7. Of the 29 pollution reference mission sensors, 24 are required by the first priority experiments. The sensors that were eliminated include: the mapping sensors 3, 4, and 11; 9, which is only used in the geology experiments; and 18, which is only required by Experiment M2.

Table 5-7. Experiment Prioritization

<table>
<thead>
<tr>
<th>Priority</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>O1 Regional water pollution monitoring</td>
</tr>
<tr>
<td></td>
<td>M4 Air pollution monitoring</td>
</tr>
<tr>
<td></td>
<td>E2 Lake Eutrophication studies</td>
</tr>
<tr>
<td>2</td>
<td>G2 Coastal geology and geomorphic processes</td>
</tr>
<tr>
<td></td>
<td>G4 Geologic and topographic mapping</td>
</tr>
<tr>
<td></td>
<td>OT3 Urban survey</td>
</tr>
<tr>
<td></td>
<td>OT2 International development project</td>
</tr>
<tr>
<td>3</td>
<td>M2 Stellar occultation</td>
</tr>
<tr>
<td></td>
<td>AFR3 Wildlife-ecosystem studies</td>
</tr>
</tbody>
</table>

The application of sensor prioritization eliminated another five sensors:

- 15 and 16 are high-resolution versions of sensors 13 and 14.
- 19 is limited to the upper atmosphere/single constituent only.
- 27 and 28 are only correlative sensors. Measurements can be obtained from other programs.

Because the technical feasibility of the laser altimeter/scatterometer (12) is questionable and the development is a long way off, it was eliminated. The elimination of this instrument does not damage the overall objectives of experiments O1 and E2.
The remaining radar (10B) ($20.2M) and the passive microwave radiometer (29) ($14.6M) were eliminated primarily because of costs. Sensor 10B was only required by experiment O1 and its elimination did not damage the experiment's integrity. In addition to being costly, Sensor 29 was primarily used for correlative support. The resulting number of low-cost pollution mission sensors was 16.

A review of the other baseline pollution reference mission experiments in terms of the 16 low-cost mission sensors shows that all the mandatory experiment sensors remain except 18, which is the only sensor required by Experiment M2. Therefore, the low-cost mission can include all but one of the baseline experiments. A comparison of low-cost and baseline versions of the pollution reference mission in terms of experiments and sensors is shown in Figure 5-2.

In addition to the low-cost mission sensors discussed above, consideration might be given to non-mandatory sensors that have a high-availability and a low-cost. As shown in Figure 5-3, three of the 13 sensors not selected fall into this category.
<table>
<thead>
<tr>
<th>NO.</th>
<th>SENSORS</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>TRACKING TELESCOPE</td>
</tr>
<tr>
<td>2</td>
<td>POINTABLE IDENT. CAMERA</td>
</tr>
<tr>
<td>3</td>
<td>PAN CAMERA</td>
</tr>
<tr>
<td>4</td>
<td>WIDE-ANGLE CAMERA</td>
</tr>
<tr>
<td>5</td>
<td>MS CAMERA</td>
</tr>
<tr>
<td>6</td>
<td>HIGH RES MS CAMERA</td>
</tr>
<tr>
<td>7</td>
<td>MULTIFREQ WIDEBAND SAR</td>
</tr>
<tr>
<td>8</td>
<td>HIGH RES MS SCANNER</td>
</tr>
<tr>
<td>9</td>
<td>LWIR SPECT</td>
</tr>
<tr>
<td>10</td>
<td>WIDEBAND SAR</td>
</tr>
<tr>
<td>11</td>
<td>MULTIFREQ WIDEBAND SAR</td>
</tr>
<tr>
<td>12</td>
<td>LASER ALT/SCAT</td>
</tr>
<tr>
<td>13</td>
<td>VIS IMAG SPECT</td>
</tr>
<tr>
<td>14</td>
<td>IR MS MECH SCANNER</td>
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<tr>
<td>15</td>
<td>HIGH RES VIS IMAG SPECT</td>
</tr>
<tr>
<td>16</td>
<td>HIGH RES IR MS SCANNER</td>
</tr>
<tr>
<td>17</td>
<td>STAR TRACK TELESCOPE</td>
</tr>
<tr>
<td>18</td>
<td>UV UPPER ATMOS SOUNDER</td>
</tr>
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<td>19</td>
<td>VIS RAD POLARIMETER</td>
</tr>
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<td>20</td>
<td>AIR POLL CORREL SPECT</td>
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<td>HIGH SPEED INTERFER</td>
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<td>22</td>
<td>CO₂ POLL EXIT</td>
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<td>23</td>
<td>GAS FILTER CORREL</td>
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<tr>
<td>24</td>
<td>ADV LIMB RAD INVERS RAD</td>
</tr>
<tr>
<td>25</td>
<td>TIROS-N ADV VERY HI RES RAD</td>
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<td>TIROS-N OPER VERT SOUNDER</td>
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<td>WIDE ANGLE/H-α VIEWER</td>
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<td>29</td>
<td>DATA COLLECT SYSTEM</td>
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**Figure 5-2. Low-Cost Pollution Reference Mission**
Figure 5-3. Low-Cost Pollution Reference Mission Definition
5.2.2 Comparison Between Low-Cost and Baseline Pollution Reference Mission

The application of the low-cost mission definition rationale to the Pollution Reference mission resulted in a substantial change in the number of sensors, power requirements and sensor costs. The orbit and data requirements remained essentially the same (see Figure 5-4).

The elimination of experiment M2 did not affect the selection of a Pollution Reference mission orbit because it did not require any targets on the earth's surface. Since the 13 sensors not considered in the low-cost version were low data rate instruments, the mission data requirement remained essentially unchanged. (Sensors 8 and 14, 200 MB/s and 7 MB/s respectively, were the primary data drivers and they were included in the low-cost version.) The elimination of the two radars (Sensors 10B and 11A, 2400W and 2300W respectively), had a substantial effect on the power requirements. The peak power required was reduced by 63 percent to 3.7 kw and the average power required was reduced by 65 percent to 1 kw. The total cost for sensors was also substantially affected by the radars ($32M) as well as the microwave radiometer (Sensor 29, $11.6M). The elimination of these sensors, as well as the other ten, reduced the total cost of sensors by 63 percent to $36M. A more detailed comparison in terms of subsystem requirements, preliminary design and costs can be found in Volumes III and IV.

* Costs include DDT&E and fabrication of first flight unit.
Figure 5-4. Pollution Reference Mission
Comparison Between Baseline and Low-Cost Versions
5.3 ADDITIONAL LOW-COST MISSIONS

In Section 5.1 the experiment prioritization was applied to all nine reference missions and the sensor prioritization was applied to all 33 sensors. By considering only the first priority experiments within each reference mission and the mandatory sensors associated with these experiments, the initial effect of the tentative low-cost mission definition rationale on Missions 2-9 can be observed. Results are shown in Tables 5-8 and 5-9. The sensor costs do not include a spare unit or data analysis and publication. If a sensor was mandatory in one or more experiments it was selected as a low-cost mission sensor. The number of sensors and the total cost of every reference mission except spring was reduced substantially (see Table 5-10). The baseline low-cost versions of the spring reference mission utilized approximately the same number of sensors because there were an exceptionally large number of Level 1 experiments.
Table 5-8. First Priority Experiments in Missions 2 through 9
Table 5-9. Mandatory Sensors in Level 1 Environment

|   | S2 | S3 | S5 | M2 | M3 | M4 | M5 | M6 | AFR1 | AFR2 | AFR3 | AFR4 | G1 | G2 | G4 | H1 | H2 | H3 | H4 | H5 | E1 | E2 | E3 | 0T1 | 0T2 | 0T3 |
|---|----|----|----|----|----|----|----|----|------|------|------|------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 2 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 3 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 4 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 5 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 6 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 7 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 8 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 9 | X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 10| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 11| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 12| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 13| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 14| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |
| 15| X  | X  | X  | X  | X  | X  | X  | X  | X    | X    | X    | X    | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |

Not Mandatory for Any Level 1 Experiments
Table 5-10. Comparison of Baseline and Preliminary Low-Cost Reference Missions

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APPENDIX A

SENSOR SPECIFICATIONS
APPENDIX A

SENSOR SPECIFICATIONS

This Appendix presents the instrument specifications for the Level 1 experiments defined in the MEO report entitled "Task 1 - Experiment Selection, Definition and Documentation." The topics addressed in the Instrument Specification Sheets are as follows:

- General Description
- Performance Characteristics
- Physical Characteristics
- Platform/Data Considerations

A summary of the instrument requirements of the Level 1 experiments is shown in Table A-1.
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<p>| TRACKING TELESCOPE | POLAR TABLED IDENTIFICATION CAMERA | PANORAMIC CAMERA | WIDE ANGLE FRAMING CAMERA | MULTISPECTRAL CAMERA SYSTEM | HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM | MULTIRESOLUTION FRAMING CAMERA SYSTEM | HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER | LWIR SPECTROMETER | WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) | WIDEBAND SYNTHETIC APERTURE RADAR (WOSAR) | ULTRAFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR | LASER ALTIMETER | VISUAL IMAGING SPECTROMETER | IR MULTISPECTRAL IMAGERY SCANNER |
|-------------------|-----------------------------------|-----------------|--------------------------|-----------------------------|-------------------------------------------|--------------------------------|-----------------------------------------------|------------------|--------------------------------------------|-----------------|---------------------------------|------------------|---------------------------------|
| TRACKING TELESCOPE | POLAR TABLED IDENTIFICATION CAMERA | PANORAMIC CAMERA | WIDE ANGLE FRAMING CAMERA | MULTISPECTRAL CAMERA SYSTEM | HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM | MULTIRESOLUTION FRAMING CAMERA SYSTEM | HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER | LWIR SPECTROMETER | WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) | WIDEBAND SYNTHETIC APERTURE RADAR (WOSAR) | ULTRAFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR | LASER ALTIMETER | VISUAL IMAGING SPECTROMETER | IR MULTISPECTRAL IMAGERY SCANNER |
| TRACKING TELESCOPE | POLAR TABLED IDENTIFICATION CAMERA | PANORAMIC CAMERA | WIDE ANGLE FRAMING CAMERA | MULTISPECTRAL CAMERA SYSTEM | HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM | MULTIRESOLUTION FRAMING CAMERA SYSTEM | HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER | LWIR SPECTROMETER | WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) | WIDEBAND SYNTHETIC APERTURE RADAR (WOSAR) | ULTRAFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR | LASER ALTIMETER | VISUAL IMAGING SPECTROMETER | IR MULTISPECTRAL IMAGERY SCANNER |
| TRACKING TELESCOPE | POLAR TABLED IDENTIFICATION CAMERA | PANORAMIC CAMERA | WIDE ANGLE FRAMING CAMERA | MULTISPECTRAL CAMERA SYSTEM | HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM | MULTIRESOLUTION FRAMING CAMERA SYSTEM | HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER | LWIR SPECTROMETER | WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR) | WIDEBAND SYNTHETIC APERTURE RADAR (WOSAR) | ULTRAFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR | LASER ALTIMETER | VISUAL IMAGING SPECTROMETER | IR MULTISPECTRAL IMAGERY SCANNER |
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</table>
INSTRUMENT SPECIFICATION No. 1

**SENSOR: TRACKING TELESCOPE**

<table>
<thead>
<tr>
<th>General Description</th>
<th>High resolution view of target area—providing pointing information to other instruments.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Variable magnification telescope with camera and sensor port, interchangeable filters and visual viewer. Controls and scanner for selection and tracking of target.</td>
</tr>
<tr>
<td>Development Status</td>
<td>Developed by Itek Corp. for Skylab B.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>Visible 400 - 700 nano-meters</td>
</tr>
<tr>
<td>IFOV</td>
<td>1/2 deg. at max. magnification, 124 x; 4 deg. at min. magnification, 16 X.</td>
</tr>
<tr>
<td>Pointing FOV</td>
<td>+70 deg. forward, -40 deg. aft, +75 deg. roll</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>5 meters/Ip at maximum magnification</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>530 ft lamberts, 2:1 contrast</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size cm (in.)</td>
<td>Dia. 43(17), Length 278(120), Elbow 55(22)</td>
</tr>
<tr>
<td>Weight Kg (lb.)</td>
<td>317 Kg (700 lbs)</td>
</tr>
<tr>
<td>Power W</td>
<td>28 V DC, 125 watts peak, average 94 watts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
<td>0.1 degree</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>0.07 degrees/sec</td>
</tr>
<tr>
<td>Data Output</td>
<td>0.66 MB/s (Angle Encoder Output Signals)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th>35 mm film camera - 250 ft/cassette</th>
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<tbody>
<tr>
<td></td>
<td>Gimbal Encoding: $2^{20}$ bits/rev. (roll), $2^{18}$ bits/rev. (pitch)</td>
</tr>
</tbody>
</table>
### SENSOR: POINTABLE IDENTIFICATION CAMERA SYSTEM (70 mm film)

#### General Description

<table>
<thead>
<tr>
<th>Function</th>
<th>Photography of target area for identification of observables.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration, Major Elements</td>
<td>Two boresighted and synchronized 70 mm film cameras, 115 mm (4.5 in.) f.4 lenses, Two-axis gimballed ±28 deg. Interchangeable filters, Image motion compensation.</td>
</tr>
<tr>
<td>Development Status</td>
<td>Similar to Skylab S190</td>
</tr>
</tbody>
</table>

#### Performance Characteristics

<table>
<thead>
<tr>
<th>Wavelength Range</th>
<th>One camera, 0.4 - 0.7μ, Panchromatic B&amp;W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Resolution</td>
<td>One camera, 0.4 - 0.7μ, Aerial Color</td>
</tr>
<tr>
<td>Field of View</td>
<td>28° x 28° 185 Km (100 n. mi.) from 370 Km altitude</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>50 m/line-pair (66 lpm lens-film AWAR, T.O.C. = 1.6/1)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>2.5 to 10 m. sec. shutter speed, f/2.8 to f/16 in half-stop increments</td>
</tr>
</tbody>
</table>

#### Physical Characteristics

<table>
<thead>
<tr>
<th>Size</th>
<th>cm (in.)</th>
<th>Cameras and Cassette</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cm (in.)</td>
<td>40 x 40 x 56 (16 x 16 x 22)</td>
</tr>
<tr>
<td>Weight</td>
<td>Kg (lbs)</td>
<td>23 (50)</td>
</tr>
<tr>
<td>Power</td>
<td>W</td>
<td>50 (av.), 80 (pk.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gimbals and Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 x 58 x 40 (28 x 23 x 16)</td>
</tr>
<tr>
<td>23 (50)</td>
</tr>
<tr>
<td>30 (av.), 100 pk.</td>
</tr>
</tbody>
</table>

#### Platform/Data Considerations

<table>
<thead>
<tr>
<th>Pointing Accuracy</th>
<th>1 degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>IMC range 10 to 30 mR/sec, controlled to 5% accuracy</td>
</tr>
<tr>
<td>Data Output</td>
<td>70 mm film, 1 frame/18 sec. for 30% overlap from orbital altitude of 370 Km (100 n. mi.)</td>
</tr>
</tbody>
</table>

#### Comments:

IMC 10 to 30 mR/sec, 5% accuracy. Film temperature control required, 68 ±5°F. 0.1 PSI pressure required, 50% relative humidity.

(1) PAN-X B&W film, Type 3400.
## INSTRUMENT SPECIFICATION No. 3

**SENSOR:** PANORAMIC CAMERA (12 cm. film)

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<th>General Description</th>
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<tbody>
<tr>
<td><strong>Function</strong></td>
<td>High resolution vertical or stereo panoramic photography</td>
</tr>
<tr>
<td><strong>Configuration, Major Elements</strong></td>
<td>Rotating optic, mirrors and focal plane slit, 1-axis gimbal, film magazine (6500 ft). 600 mm (24 in.) f/1, refractive optic, f/3.5 relative aperture.</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>Flown on Apollo 15. More than 50 units built for aircraft.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
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</thead>
<tbody>
<tr>
<td><strong>Wavelength Range</strong></td>
<td>0.52 - 0.72 μ (Achromat Lens), 0.425 - 0.9 μ (Apochromat Lens)</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>0.2 μ</td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
<td>12° (along-track), 120° (cross-track)</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>135 τpm at 2/1 T, O, C, 3404 film. 5 m/τ, p from H = 370 Km.</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>Exposure interval 0.39 to 29 m sec. Automatic exposure control and forward motion compensation.</td>
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</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
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<tbody>
<tr>
<td><strong>Size</strong></td>
<td>152 x 74.5 x 65 (60 x 29.3 x 25)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>129 (283) space envir., 91 (200) shirtsleeve envir.</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>234 W. (av.), 28 V. DC and 115 V, 30, 400 Hz</td>
</tr>
<tr>
<td><strong>Lens temperature controlled to +50°F</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
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<tbody>
<tr>
<td><strong>Pointing Accuracy</strong></td>
<td>0.5 degree</td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
<td>5 to 25 mR/sec (gimbal programmed for V/h)</td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
<td>11.5 x 128 cm negatives, B&amp;W, color, or color IR. Continuous stereo obtained by nodding +12.5° from nadir.</td>
</tr>
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</table>

**Comments:** Use in conjunction with Wide Angle Framing Camera (No. 4) for mapping. Recommended for multiple use mapping and map updating.
## INSTRUMENT SPECIFICATION No. 4

### SENSOR: WIDE ANGLE FRAMING CAMERA (24 x 48 cm. film)

### General Description

**Function**
- Planimetric and topographic surveys of the terrain.

**Configuration, Major Elements**
- Metric camera with 300 mm (12 in.) focal length lens. Frame size 24 x 48 cm. (9 x 18 in.) long dimension oriented along flight line to obtain overlap.
- Calibrated reseau for geometric reference, rotating disc (between-the-lens) shutter. Image motion compensation.

**Developmental Status**
- Sim., equipt, operational in aircraft. Dev. for space flight req.

### Performance Characteristics

**Wavelength Range**
- B/W Panchromatic Film, 0.5 - 7μ

**Spectral Resolution**
- 0.2μ

**Field of View**
- 41° x 74°, gimbal ±28° cross-track (mapping), ±60° (Expr. M-1)

**Spatial Resolution**
- 60 2pm lens-film AWAR, TOC = 1,6/1 (20 m/l-p from H = 370 Km)

**Sensitivity**
- 1 to 10 m sec. shutter speed, continuously variable.
- f/6.3 to f/22 in half-stop increments

### Physical Characteristics

**Camera and Cassette**
- Size: 55 x 66 x 83 (22 x 26 x 33)
- Weight: 68.5 (150)
- Power: 170 (av.), 224 (pk.)

**Gimbals and Control**
- Size: 72 x 58 x 40 (28 x 23 x 16)
- Weight: 61 (135)
- Power: 80 (av.), 250 (pk.)

**Film temp. control to 68 ±5°F, 0.1 PSI, 50% rel. humidity**

### Platform/Data Considerations

**Pointing Accuracy**
- 1.0 degree

**Line of Sight Rate (max.)**
- IMC range 10 to 30 mR/sec, 5% accuracy

**Data Output**
- 24 x 48 cm (9 x 18 in. film)

### Comments:

Use in conjunction with Panoramic Camera (No. 3) for mapping.

---

(1) PAN-X B&W film, Type 3400.
## INSTRUMENT SPECIFICATION No. 5

**SENSOR: MULTISPECTRAL CAMERA SYSTEM (24 x 24 cm, film)**

### General Description

**Function**
- a) Multispectral photography, wide coverage, high resolution
- b) B/W and color photography, wide coverage, high resolution

**Configuration, Major Elements**
- Six boresighted mapping cameras (Type RC-10 or equiv.)
- 460 mm (18 in.) f/1. lenses, Gimbaled ±28° cross-track.
- Camera selection (2 or 6) and filter selection required.
- Image motion compensation.

**Developmental Status**
- Operational in aircraft. Development for space flight required.

### Performance Characteristics

#### Wavelength Range
1. 0.5 - 0.6µ B&W
2. 0.6 - 0.7µ B&W
3. 0.7 - 0.8µ B&W IR
4. 0.8 - 0.9µ B&W IR
5. 0.5 - 0.88µ, false color
6. 0.5 - 0.7µ, aerial color

#### Field of View
- 28° x 28°, 185 x 185 Km (100 x 100 n. mi.) from 370 Km altitude

#### Spatial Resolution
- 12.5 m/line-pair (66 fpm lens-film AWAR, TOC = 1.6/1)\(^{(1)}\)

#### Sensitivity
- 1 to 10 mSec shutter speed, continuously variable.
- f/4.5 to f/16 in half-stop increments.

### Physical Characteristics

**Cameras and Cassettes**
- 147 x 105 x 97 (58x41x38) \(^{(2)}\)

**Gimbals and Control**
- 172 x 109 x 68 (68x43x27)

**Weight**
- 760 (1670) (6 cameras)
- 364 (800)

**Power**
- 500/1500 (2/6 cameras)
- 500 (Av.), 1500 (Pk.)

**Film Temp. Control**
- to 68 ±5°F, 0.1 PSI, 50% Rel. Humidity

### Platform/Data Considerations

**Pointing Accuracy**
- 1.0 degree

**Line of Sight Rate**
- IMC Range 10 to 30 mR/Sec., controlled to 5% accuracy

**Data Output**
- 24 x 24 cm (9 x 9 in.) film

### Comments:

- (1) PAN-X B&W film, Type 3400.
- (2) Specifications for six cameras.
### SENSOR: HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film)

<table>
<thead>
<tr>
<th>General Description</th>
<th>High resolution multispectral photography of selected target areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Six boresighted and synchronized 70 mm film cameras, 1800 mm (72 in.) f.1 Catadioptric lenses. Two-axis gimbaling +40°, slaved to tracking telescope. Interchangeable filters. Image motion compensation by rate gyro control. Similar to Skylab S190.</td>
</tr>
<tr>
<td>Configuration, Major Elements</td>
<td>1800 mm (72 in.) f.1 Catadioptric lenses. Two-axis gimbaling +40°, slaved to tracking telescope. Interchangeable filters. Image motion compensation by rate gyro control. Similar to Skylab S190.</td>
</tr>
</tbody>
</table>

### Performance Characteristics

<table>
<thead>
<tr>
<th>Wavelength Range</th>
<th>1. 0.5-0.6μ, B&amp;W 4. 0.8-0.9μ, B&amp;W IR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. 0.6-0.7μ, B&amp;W 5. 0.5-0.88 false color</td>
</tr>
<tr>
<td></td>
<td>3. 0.7-0.8μ, B&amp;W IR 6. 0.4-0.7 aerial color</td>
</tr>
<tr>
<td>Field of View</td>
<td>1.75 x 1.75°, 11.6 Km. (6.25 n. mi.) from 370 Km altitude.</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>6 m/line-pair (35 l pm lens-film AWAR, TOC = 1.6/10)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>2,5 to 50 m. sec. shutter speed, f/6.3 to f/16 in half-stop increments.</td>
</tr>
</tbody>
</table>

### Physical Characteristics

<table>
<thead>
<tr>
<th>Size cm. (in.)</th>
<th>90 x 100 x 72 (35x39x28) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Kg (lbs)</td>
<td>90.7 (200)</td>
</tr>
<tr>
<td>Power W</td>
<td>100 (av.) 300 (pk.)</td>
</tr>
<tr>
<td></td>
<td>140 x 80 x 63 (55x32x25)</td>
</tr>
<tr>
<td></td>
<td>63.5 (140)</td>
</tr>
<tr>
<td></td>
<td>60 (av.) 300 pk.</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

<table>
<thead>
<tr>
<th>Pointing Accuracy</th>
<th>0.2 degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>IMC range 10 to 30 mR/sec, controlled to 5% accuracy</td>
</tr>
<tr>
<td>Data Output</td>
<td>70 mm film</td>
</tr>
</tbody>
</table>

### Comments:

IMC provided by rate gyro control, Film temperature control to 68 ±5°F, 0.1 PSI pressure, 50% relative humidity.

---

(1) Ektrachrome IR Aero film, Type 8493
(2) Specifications for six cameras
## SENSOR: MULTiresolution Camera System (24 x 24 cm. film)

<table>
<thead>
<tr>
<th>General Description</th>
<th>False color photography of earth resources with three different values of spatial resolution.</th>
<th>Three boresighted mapping cameras (Type RC-10 or equiv.) 460, 920, 1840 mm (18, 36, 72 in.) f.l. lenses. Gimbaled +28° cross-track. Image motion compensation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration, Major Elements</td>
<td></td>
<td>Operational in aircraft. Development for space flight required.</td>
</tr>
<tr>
<td>Developmental Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Characteristics</td>
<td>Wavelength Range</td>
<td>0.50 - 0.88μ (Ektachrome Infrared Aero-False Color)</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>0.38μ</td>
<td></td>
</tr>
<tr>
<td>Field of View</td>
<td>28°/14°/7.5°, 185 x 185/92 x 92/46 x 46 Km from 370 Km alt.</td>
<td></td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>25/12, 5/6, 2 m/line-pair (33 2pm AWAR T. O. C. = 1.6/1)</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1 to 10 msec shutter speed, continuously variable f/4.5 to f16 in half-stop increments</td>
<td></td>
</tr>
<tr>
<td>Physical Characteristics</td>
<td>Cameras and Cassettes</td>
<td>Gimbals and Control</td>
</tr>
<tr>
<td>Size cm. (in.)</td>
<td>148 x 105 x 43 (58 x 41 x 17) (^{(1)})</td>
<td>172 x 68 x 50 (68x40x20)</td>
</tr>
<tr>
<td>Weight Kg (Lb.)</td>
<td>380 (835) (3 cameras)</td>
<td>182 (400)</td>
</tr>
<tr>
<td>Power W</td>
<td>750 (3 cameras)</td>
<td>250 (Av.), 750 (Pk.)</td>
</tr>
<tr>
<td>Platform/Data Considerations</td>
<td>Pointing Accuracy</td>
<td>0.5 deg.</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>IMC Range 10 to 30 mR/sec; controlled to 5% accuracy</td>
<td></td>
</tr>
<tr>
<td>Data Output</td>
<td>24 x 24 cm. (9 x 9 in.) film</td>
<td></td>
</tr>
<tr>
<td>Film Temp. Control to 68 ±5°F, 0.1 PSI, 50% relative humidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td>Use Wild NF-2 Navigation Sight (or equivalent) (Instrument No. 32) in conjunction with this system. (\text{Catadioptric lens should be considered for 1840 mm f.l. lens})</td>
<td></td>
</tr>
</tbody>
</table>

\(^{(1)}\) Specifications for three cameras
# SENSOR: HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER

<table>
<thead>
<tr>
<th>General Description</th>
<th>To obtain multispectral imagery of the terrain for use in agricultural, forestry, geological, and hydrological observations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Elements</td>
<td></td>
</tr>
</tbody>
</table>

## Developmental Status

**Performance Characteristics**

<table>
<thead>
<tr>
<th>Wavelength Range</th>
<th>0.4–1.0 µ (9 bands), 1–5 µ (5 bands), 8–13 µ (6 bands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Resolution</td>
<td>(0.4–1.0 µ), 0.05 µ, (1–5 µ) 0.12 to 0.45 µ, (8–13 µ) 0.5 to 1.0 µ</td>
</tr>
<tr>
<td>Field of View</td>
<td>(0.4–1.0 µ) 87 µ, (1–5 µ) 87 µ, (8–13 µ) 173 µ</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>(0.4–1.0 µ) 30 m, (1–5 µ) 30 m, (8–13 µ) 60 m</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>(0.4–1.0 µ) NEΔρ = 1%, (1–5 µ) NEΔρ = 1–2.5%, (8–13 µ) NEΔT = 1–2°K</td>
</tr>
<tr>
<td>No. Detectors/Band</td>
<td>(0.4–1.0 µ) 2, (1–5 µ) 2, (8–13 µ) 1</td>
</tr>
</tbody>
</table>

## Physical Characteristics

<table>
<thead>
<tr>
<th>Size (cu. m. (ft³))</th>
<th>Scanner</th>
<th>V-M Cooler</th>
<th>Electronic Asmb.</th>
<th>Gimbal Sys.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.51 (18)</td>
<td>0.05 (0.16)</td>
<td>0.034 (1.2)</td>
<td>0.42 (15)</td>
<td></td>
</tr>
<tr>
<td>Weight (Kg (lb))</td>
<td>100 (225)</td>
<td>3.7 (8)</td>
<td>34 (75)</td>
<td>63.5 (190)</td>
</tr>
<tr>
<td>Power (W)</td>
<td>266</td>
<td>45</td>
<td>(incl. in scanner)</td>
<td>300 (pk.)</td>
</tr>
</tbody>
</table>

## Platform/Data Considerations

<table>
<thead>
<tr>
<th>Pointing Accuracy</th>
<th>0.5 degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>3 arc-min/sec (max.)</td>
</tr>
<tr>
<td>Data Output</td>
<td>200 MB/S PK (8-bit encoding, 33% duty cycle), all 20 bands. Data recording limitation may require use of only selected bands.</td>
</tr>
<tr>
<td>Comments:</td>
<td>Pointable ±22° cross-track (one-axis gimbals) Swath width = 62 Km (33 n. mi.), IFOV = 30 &amp; 60 m (H = 370 Km) Conical scan, 7200 RPM, 33% scan efficiency.</td>
</tr>
</tbody>
</table>
### INSTRUMENT SPECIFICATION No. 9

**SENSOR:** LONG WAVELENGTH INFRARED SPECTROMETER

<table>
<thead>
<tr>
<th><strong>General Description</strong></th>
<th><strong>Function</strong></th>
<th>Geologic Surveys - Identification of types of rock, sand, sediments, and soils.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Configuration,</strong></td>
<td><strong>Configuration,</strong></td>
<td>Cassegrain Telescope (25 cm. dia.), 2-band spectrometer, radiometer, pointing mirror, roll gimbal, visual viewer and identification camera.</td>
</tr>
<tr>
<td><strong>Major Elements</strong></td>
<td><strong>Developmental Status</strong></td>
<td>Similar to Skylab S-191 with radiometric channel added.</td>
</tr>
</tbody>
</table>

| **Performance Characteristics** | **Wavelength Range** | Spectrometry (0.4-2.4μ, 6.2-15.5μ), radiometry (10.1-12.5μ) |
|                               | **Spectral Resolution** | Spectrometry (0.1-0.5μ, 0.1-0.3μ), radiometry (2.4μ) |
|                               | **Field of View** | 1 m Rad, gimbaled +45°, -10° along track, ±20° cross track |
|                               | **Spatial Resolution** | 0.37 Km from orbital altitude of 370 Km |
|                               | **Sensitivity** | (0.4-2.4μ) 1.2 to 8 x 10⁻⁵ w/cm²-st, (6.2-15.5μ) 1.5 to 8 x 10⁻⁵ w/cm²-st. Temperature 0.1 K° |

| **Physical Characteristics** | **Size** | cm. (in.) 51 x 51 x 130 (20 x 20 x 51) |
|                             | **Weight** | Kg (lb.) 182 (402) |
|                             | **Power** | W 200 (av.) |

| **Platform/Data Considerations** | **Pointing Accuracy** | 0.3 degree (manual pointing by astronaut) |
|                                 | **Line of Sight Rate (max.)** | 0.1 m R/sec |
|                                 | **Data Output** | Spectrometry 684 samples/sec x 10-bit encoding = 6.84 KB/S Spectral scan rate = 1/sec. Radiometry 10 S/S, 10-bit, 100 B/S |

<p>| <strong>Comments:</strong> | | Operates in target tracking mode. |</p>
<table>
<thead>
<tr>
<th><strong>INSTRUMENT SPECIFICATION No. 10A</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SENSOR:</strong> WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR)</td>
</tr>
<tr>
<td><strong>(WIDE COVERAGE, LOW RESOLUTION MODE)</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>General Description</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Radar mapping of ice fields by contrast with sea water scattering</td>
</tr>
<tr>
<td><strong>Configuration,</strong> Major Elements</td>
<td>Antenna, transmitter, 2 receivers, 2 film recorders, power supply</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>Development for space required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Performance Characteristics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength Range</strong></td>
<td>10 GHz</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>50 MHz Bandwidth</td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
<td>250 Km Swathwidth (from 370 Km altitude)</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>100 m</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>$\sigma_o &gt; -20$ dB</td>
</tr>
<tr>
<td><strong>Beam Depression Angle</strong></td>
<td>34 deg., Beamwidth=12 deg.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Physical Characteristics m$^3$(ft$^3$)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>$T_X/R_X$ 0.1(3), Rec. 0.7(24), p.s. 0.06(2)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Antenna 8.7 x 0.35 x 0.2 (28.3 x 1.15 x 0.5), 6.1 m$^3$ (22 ft$^3$)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>275 (600) total; ant. 70(150), $T_X/R_X$ 70(150), rec. 90(200), power supply 45 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Platform/Data Considerations</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pointing Accuracy</strong></td>
<td>0.5 degree</td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
<td>1.5 m/s/sec</td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
<td>Data recorded on film</td>
</tr>
</tbody>
</table>

| **Comments:** | Transmits single polarization. Receives dual polarization. Experiments O2, M6, H2.  |
### INSTRUMENTATION SPECIFICATION No. 10B

**SENSOR:** WIDE BAND SYNTHETIC APERTURE RADAR (WBSAR)  
(MEDIUM COVERAGE, HIGH RESOLUTION MODE)

<table>
<thead>
<tr>
<th>General Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Radar images of ocean surface backscattering for determination of pollution and wind patterns</td>
</tr>
<tr>
<td><strong>Configuration,</strong> Major Elements</td>
<td>Antenna, transmitter, 2 receivers, 2 film recorders, power supply</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>Development for space required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength Range</strong></td>
<td>10 GHz</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>50 MHz Bandwidth</td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
<td>100 Km Swathwidth (from 370 Km altitude)</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>30 meters at 200 n. mi. altitude</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>$\sigma_o &gt; -25 \text{ dB/5 knot wind}$</td>
</tr>
<tr>
<td><strong>Beam Depression Angle</strong></td>
<td>$60 \text{ deg.}, \text{ Beamwidth} \approx 12 \text{ deg.}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong> $m^3 (ft^3)$</td>
<td>$T_X/R_X 0.1(3), \text{ rec. 0.7(24), p. s. 0.06(2)}$</td>
</tr>
<tr>
<td><strong>Weight</strong> Kg (lb)</td>
<td>Antenna $8.7 \times 0.35 \times 0.2 \text{ (28.3 x 1.15 x 0.5)}, 6.1 m^3 \text{ (22 ft^3)}$</td>
</tr>
<tr>
<td><strong>Power</strong> W</td>
<td>$275(600) \text{ Total; Ant. 70(150), } T_X/R_X 70(150), \text{ rec. 90(200)}$</td>
</tr>
<tr>
<td><strong>Platform/Data Considerations</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Pointing Accuracy</strong></td>
<td>0.5 degree</td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
<td>0.6 mtr/sec</td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
<td>Data recorded on film</td>
</tr>
</tbody>
</table>

**Comments:** Transmits single polarization. Receives dual polarization. Experiments Ol, O5, H3.
| **SENSOR:** MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR)  
(MEDIUM COVERAGE, LOW RESOLUTION MODE) |  |
| --- | --- |
| **General Description**  
Function | Radar images of surface backscattering for determination of soil conditions and crops identification.  
Configuration, Major Elements | 3 antennas; 3 transmitters; 6 receivers; 6 film recorders, power supply.  
Developmental Status | SR and T and development required |
| **Performance Characteristics**  
Wavelength Range | 3, 5.5, and 10 GHz  
Spectral Resolution | 50 MHz Bandwidth  
Field of View | 120 Km Swathwidth (from 370 Km altitude)  
Spatial Resolution | 30 meters at 200 n. mi. altitude  
Sensitivity | $r_0 > -18$ dB  
Beam Depression Angle | 60 deg., Beamwidth = 14.5 deg. |
| **Physical Characteristics m$^3$ (ft$^3$)**  
Size | $T_X/R_X$ 0.25(9), rec. 2.1(76), p.s. 0.1(3)  
Weight | Antenna 8.7 x 1.8 x 0.2 (28.3 x 6 x 0.5), $3.14$ m$^3$ (111 ft$^3$)  
Power | 945 (2075) total; ant. 375 (825), $T_X/R_X$ 210 (450), recorders 2300 |
| **Platform/Data Considerations**  
Pointing Accuracy | 0.5 degree  
Line of Sight Rate (max.) | 0.6 mr/sec  
Data Output | Data recorded on film |
| **Comments:** | Transmits single polarization, receives dual polarization.  
Experiments G1, G2, G4, H4, H5 |
## INSTRUMENT SPECIFICATION No. 11B

**SENSOR:** MULTI-FREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR (MFWBSAR)  
(NARROW COVERAGE, HIGH RESOLUTION MODE)

<table>
<thead>
<tr>
<th>General Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Radar images of surface backscattering</td>
</tr>
<tr>
<td><strong>Configuration, Major Elements</strong></td>
<td>3 antennas; 3 transmitters; 6 receivers; 6 film recorders; power supply</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>SRT and development required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength Range</strong></td>
<td>3, 5.5, and 10 GHz</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>50 MHz Bandwidth</td>
</tr>
<tr>
<td><strong>Field of View Km</strong></td>
<td>72 Km Swathwidth (from 370 Km altitude)</td>
</tr>
<tr>
<td><strong>Spatial Resolution m (ft)</strong></td>
<td>15 (50 ft)</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>$\sigma_o &gt; -20$ dB</td>
</tr>
<tr>
<td><strong>Beam Depression Angle</strong></td>
<td>60 deg., Beamwidth $\approx 8.6$ deg.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics $m^3 (ft^3)$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size $m^3 (ft^3)$</strong></td>
<td>$T_X/R_X$ 0.25 (9), rec. 2.1 (76), p.s. 0.1 (3)</td>
</tr>
<tr>
<td><strong>Weight Kg (lb)</strong></td>
<td>Antenna 8.7 x 3 x .20 (28.3 x 10 x 0.6 ft), 5.2 $m^3$ (185 $ft^3$)</td>
</tr>
<tr>
<td><strong>Power W</strong></td>
<td>945 (2075) total; ant. 375(825), $T_X/R_X$ 210 (450), recorders 2300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pointing Accuracy</strong></td>
<td>0.5 degree</td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
<td>0.3 mr/sec</td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
<td>Data recorded on film</td>
</tr>
</tbody>
</table>

| Comments:                   | Transmits single polarization, receives dual polarization. Experiments AFR1, AFR2, El, OT2 |
### General Description

**Function**

a) Profiling of mountainous terrain; b) Determination of wind and wave statistics on ocean surface; c) Determination of surface texture of ice and snow fields; d) Profiling of chlorophyll depth below ocean surface.

**Configuration,**

Nd:YAG laser, Q-switched, optical frequency doubling.

**Major Elements**

T/R switched mirror, reflective optics, PMT detector.

**Developmental Status**

Development required, chlorophyll profiling feasibility TBD.

### Performance Characteristics

- **Wavelength Range**: 0.53μ, 7.5 n sec. pulse width, 0.7 Joule/pulse, 3 pps
- **Spectral Resolution**: NA
- **Field of View**
  - Transmitter: 10 μRad., Receiver: 1 m Rad.
- **Spatial Resolution**: 4 m from orbital altitude of 370 Km (200 n. mi.)
- **Range Accuracy**: 25 cm.

### Physical Characteristics

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Optical Asmb.</th>
<th>Electronic Asmb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>20 dia. x 30 (16 dia. x 32)</td>
<td>20 x 25 x 30 (8x10x12)</td>
</tr>
<tr>
<td>Weight</td>
<td>18 (40)</td>
<td>11.4 (25)</td>
</tr>
<tr>
<td>Power</td>
<td>150</td>
<td>30</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

- **Pointing Accuracy**: 0.1 degree
- **Line of Sight Rate (max.)**: 0.05 deg/sec.
- **Data Output**: 150 BPS

### Comments:

See TRW EOS Coastal Oceanographic Requirement Study pp 5-68 to 5-79 for design details.
### INSTRUMENT SPECIFICATION No. 13

#### SENSOR: VISIBLE IMAGING SPECTROMETER

<table>
<thead>
<tr>
<th><strong>General Description</strong></th>
<th><strong>Performance Characteristics</strong></th>
<th><strong>Physical Characteristics</strong></th>
<th><strong>Platform/Data Considerations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Wavelength Range</td>
<td>One Instrument</td>
<td>One Instrument</td>
</tr>
<tr>
<td><strong>Configuration, Major Elements</strong></td>
<td>Spectrometry and imaging of ocean surface color to identify organic matter, sedimentation, and pollution.</td>
<td>.4 - .7 µ</td>
<td>18 x 18 x 48 (7x7x19)</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>Imaging spectrometer; objective lens, collimating lens, diffraction grating, re-imaging lens, image dissector.</td>
<td>.015µ (20 spectral bands), 150 spatial elements</td>
<td>18 x 8 x 48 (7x32x19)</td>
</tr>
<tr>
<td><strong>MOCS (Multichannel Ocean Color Sensor) developed by TRW Systems and flown under AAFE program.</strong></td>
<td>Field of View</td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td><strong>Wavelength Range</strong></td>
<td>Spectral Resolution</td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td><strong>2.0 m R x 17.1° (one sensor), (2.0 m R x 51.3° (3 sensors)</strong></td>
<td>.015µ (20 spectral bands), 150 spatial elements</td>
<td>18 x 82 x 48 (7x32x19)</td>
<td>69 (150)</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>Spatial Resolution</td>
<td>18 x 8 x 48 (7x32x19)</td>
<td>75</td>
</tr>
<tr>
<td><strong>0.74 Km (0.4 n. mi.) from orbital altitude of 370 Km (200 n. mi.)</strong></td>
<td>Sensitivity</td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td><strong>NEA P = .001</strong></td>
<td>Absolute Accuracy</td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td><strong>10% absolute, 0.2% relative radiometry</strong></td>
<td>Physical Characteristics</td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td><strong>Size cm. (in.)</strong></td>
<td><strong>Weight Kg (lb)</strong></td>
<td>18 x 18 x 48 (7x7x19)</td>
<td>69 (150)</td>
</tr>
<tr>
<td>18 x 82 x 48 (7x32x19)</td>
<td>23 (50)</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td><strong>Power W</strong></td>
<td><strong>Data Output</strong></td>
<td>One Instrument</td>
<td>Three Instruments</td>
</tr>
<tr>
<td>25</td>
<td>126 KB/S for 20 channels</td>
<td>One sensor will give swath width of 112 Km (60 n. mi.)</td>
<td>Same</td>
</tr>
<tr>
<td>(12 bit encoding, 3.5 frames/sec)</td>
<td><strong>Comments:</strong></td>
<td>Three sensors will give swath width of 398 Km (214 n. mi.)</td>
<td>Same</td>
</tr>
<tr>
<td><strong>SENSOR:</strong> IR - MULTISPECTRAL MECHANICAL SCANNER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General Description</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration, Major Elements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development Status</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Performance Characteristics**                 |
| Wavelength Range                                | 0.2 - 4.0µ (clouds-daytime), 3.6 - 4.1µ (clouds-night) |
| Field of View                                   | Conical scan 30° from nadir. 120° active. |
| Spatial Resolution                              | IFOV = 2 x 2 m Rad. Ground Resolution = 0.74 x 0.85 Km (H = 370 Km) |
| Sensitivity                                      | 0.12 K (10.5 - 11.5µ), 0.2 K (8.55 - 9.35µ) |

| **Physical Characteristics**                    |
| Size                                            | Conical configuration, 25 cm dia. at top, 80 cm dia. at bottom, 65 cm height. (add 15x15x20 cm for V-M cooler, if used) |
| Weight                                          | 43 (95) (add 3.7 (6) for V-M cooler, if used) |
| Power                                           | 45 (add 45 W for V-M cooler, if used) |

| **Platform/Data Considerations**                |
| Pointing Accuracy                               | 1.0 degree |
| Line of Sight Rate (max.)                       | 2 m Rad/sec (at orbital altitude of 370 Km) |
| Data Output                                     | 7.45 MB/S (33% duty cycle), 2.5 MB/S with data stretching 5.0 MB/S if both forward and aft scan used (67% duty cycle) |

| **Comments:**                                   |
| Spectral bands same as EOS Sea Surface Temperature Imaging Radiometer. (Configuration defined in TRW Global Oceanographic Requirement Study, Jan-1972, pp 7-43.) |
# Instrument Specification No. 15

## Sensor: High Resolution Visible Imaging Spectrometer

### General Description

| Function | Imaging spectrometer; catadioptric (telephoto) objective lens, collimating lens, grating, re-imaging lens, image dissector. |
| Configuration, Major Elements | Similar to TRW Multichannel Ocean Color Sensor but uses smoothing (integrating) image dissector |

### Performance Characteristics

| Wavelength Range | 0.4 - 0.7µ |
| Spectral Resolution | 0.015µ (20 spectral bands) |
| Field of View | IFOV = 0.38 x 0.38 m R, FOV = 0.38 m R x 3.42 deg. |
| Spatial Resolution | 0.38 m R (140 m from orbital altitude of 370 Km) |
| Sensitivity | 10% absolute, 0.2% relative radiometry |

### Physical Characteristics

| Sensor | Gimbals & Control(1) |
| Size | 18 x 18 x 63 (7x7x25) | 42 x 73 x 76 (17x25x30) |
| Weight | 13.6 (30) | 22.8 (50) |
| Power | 25 | 50 (av.) 200 (pk) |

### Platform/Data Considerations

| Pointing Accuracy | 0.3 degree |
| Line of Sight Rate (max.) | 0.02 m R/sec |
| Data Output | 6 KB/S (12 bit encoding, 6 sec/frame) (20 spectral bands, 150 TVL/frame) |

### Comments:

Similar to Instrument No. 13 but uses telephoto rather than wide angle lens. Rate gyro stabilization required.

---

(1) Gimbal system used for both Instrument No. 15 and Instrument No. 16.
<table>
<thead>
<tr>
<th><strong>SENSOR:</strong> HIGH RESOLUTION IR MULTISPECTRAL SCANNER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Description</strong></td>
</tr>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td><strong>Configuration, Major Elements</strong></td>
</tr>
<tr>
<td><strong>Development Status</strong></td>
</tr>
<tr>
<td><strong>Performance Characteristics</strong></td>
</tr>
<tr>
<td><strong>Wavelength Range</strong></td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
</tr>
<tr>
<td><strong>Physical Characteristics</strong></td>
</tr>
<tr>
<td><strong>Size cm (in.)</strong></td>
</tr>
<tr>
<td><strong>Weight Kg (lb)</strong></td>
</tr>
<tr>
<td><strong>Power W</strong></td>
</tr>
<tr>
<td><strong>Platform/Data Considerations</strong></td>
</tr>
<tr>
<td><strong>Pointing Accuracy</strong></td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
</tr>
<tr>
<td><strong>Development for space flight required.</strong></td>
</tr>
</tbody>
</table>

- General Description: Thermal mapping of the sea surface, effect of water vapor removed from data by using three IR spectral bands. Additional spectral bands to measure cloud cover.
- Configuration, Major Elements: Cassegrain optical system, 28 cm dia., f/8.0, two-axis plane mirror scanner (raster scan), HgCdTe detectors for IR bands, Vellumier closed-cycle or passive radiative cooler.
- Development Status: Development for space flight required.
- Performance Characteristics:
  - Wavelength Range: 0.2 - 0.4μ (clouds-daytime), 3.6 - 4.1μ (clouds-night), 6.5 - 7.0μ (H2O), 8.85 - 9.35μ (H2O), 10.5 - 11.5μ (IR window)
  - Field of View: IFOV = 0.41 x 0.41 m Rad, Total FOV = 61 x 61 m Rad.
  - Spatial Resolution: 150 m from orbital altitude of 370 Km (200 n. mi.)
  - Sensitivity: NEAT = 0.09 K (10.5 - 11.5μ), 0.15 K (8.85 - 9.35μ) (150 x 150 Element Raster Scan) (Frame Scan Time = 4.7 sec.)
- Physical Characteristics:
  - Size cm (in.): 20 x 20 x 60 (8x8x24)
  - Weight Kg (lb): 16 (35)
  - Power W: 35
- Platform/Data Considerations:
  - Pointing Accuracy: 0.3 degree
  - Line of Sight Rate (max.): 1 m R/sec (H = 370 Km)
  - Data Output: 240 KB/S (10 - Bit Encoding)
- Comments: Spectral bands identical to EOS Sea Surface Temperature Image Radiometer. Rate gyro stabilization required.
**SENSOR: GLITTER FRAMING CAMERA**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Primary: To obtain images of solar and lunar glitter pattern to deduce avg sea state and locate areas of reduced sea state. Secondary: To obtain moderate resolution images of areas outside glitter pattern.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>800 TV line camera (SEC Vidicon); f/2 optics with adjustable iris diaphragm f/2 to f/16; 2 axis gimballing or 2 axis pointing mirror.</td>
</tr>
<tr>
<td>Configuration, Major Elements</td>
<td>State-of-the-art, development required.</td>
</tr>
<tr>
<td>Performance Characteristics</td>
<td>Wavelength Range: 0.58-0.7µ - not critical but should be at red end of visible spectrum (solar), 0.4 - 0.7µ (lunar). Spectral Resolution: 0.22, 0.30µ. Field of View: 40° x 40°; Pointable ±53° on two axes from nadir. Spatial Resolution: 0.85 m Rad., 315 m/TVL from 370 Km (200 n. mi.) altitude. Sensitivity: 64:1 dynamic range at any given exposure, additional 16:1 by varying exposure. Absolute Accuracy: 20 percent photometric.</td>
</tr>
<tr>
<td>Physical Characteristics</td>
<td>Camera</td>
</tr>
<tr>
<td>Size</td>
<td>10 x 16</td>
</tr>
<tr>
<td>cm. (in.)</td>
<td>40(4x6x16)</td>
</tr>
<tr>
<td>Weight</td>
<td>3.6 (8)</td>
</tr>
<tr>
<td>Kg (lb)</td>
<td>10</td>
</tr>
<tr>
<td>Power</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Platform/Data Considerations</td>
<td>Pointing Accuracy: 1.0 degree. Line of Sight Rate (max.): 0.35 deg./sec. Data Output: 1.2 MB/s (6-bit) video, 10 sec/frame, 1 frame/30 sec.</td>
</tr>
<tr>
<td>Comments:</td>
<td>Brightness at center of solar glitter pattern varies from about 200 to 2500 Lum/ft²/ster. Lunar glitter pattern varies from 3x10⁻² to 4x10⁻² Lum/ft²/ster. 2 frames/min. give about 4 images of any point on surface.</td>
</tr>
</tbody>
</table>
**SENSOR: STAR TRACKING TELESCOPE**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Measurement of change in refraction angle of stars prior to occultation to determine atmospheric density.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Boresighted acquisition (Vidicon) star tracker and data (image dissector) star tracker mounted on 3-axis gimbal system. Rate gyro reference 0.01 deg./hr drift rate. Pulse-torque gyro control.</td>
</tr>
<tr>
<td>Configuration, Major Elements</td>
<td>CRT display, recording camera. Stage of the art equipment. Development required.</td>
</tr>
<tr>
<td>Developmental Status</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>0.4 - 0.7 microns</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>0.4 - 0.7 microns</td>
</tr>
<tr>
<td>Field of View</td>
<td>Acquisition star tracker 5° x 5°. Data star tracker 10 x 10 arc-min.</td>
</tr>
<tr>
<td>Angular Accuracy</td>
<td>Instrument: 3 arc-sec. Data Star Tracker: 2 arc-sec. 1 arc-sec. resolution.</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>+6 visual magnitude.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Star Tracking Instrument</th>
<th>Electronic Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (cm, in.)</td>
<td>141 (55.5) x 107 (42.1) dia.</td>
<td>30 x 30 x 30 (11,8 x 11,8 x 11,8)</td>
</tr>
<tr>
<td>Weight (Kg, lb.)</td>
<td>41 (90)</td>
<td>16 (35)</td>
</tr>
<tr>
<td>Power (W)</td>
<td>150 pk./80 av.</td>
<td>75 pk./50 av.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
<td>0.25 degree</td>
</tr>
<tr>
<td>Line of Sight Rate</td>
<td>4 deg./min, orbital rate + 3 arc-min/sec. (max.) refraction rate</td>
</tr>
<tr>
<td>Data Output</td>
<td>Time 26 bits, mode 14 bits, gyros (2) 28 bits, errors (2) 14 bits, AGC 7 bits, 10 samples/sec, 890 B/S total. 5 min. of data/sighting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Angle Range</td>
<td>90 deg. to 70 deg. from nadir (aft) in pitch, +30 deg. from orbital plane (aft) in azimuth.</td>
</tr>
<tr>
<td>Similar to Apollo Applications &quot;A&quot; Experiment No. S-047. except instrument is configured for remote operation. Concurrent radiosonde measurements required.</td>
<td></td>
</tr>
</tbody>
</table>
## INSTRUMENT SPECIFICATION No. 19

**SENSOR: UV UPPER ATMOSPHERIC SOUNDER (UVUAS)**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Measure altitude profiles and secular changes in upper atmospheric constituents (O₃ from 30 to 55 km altitude and NO from 60 to 90 km altitude).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Telescope with MgF₂ optics, scanning Ebert Grating spectrometer, control and data handling electronics, 2-axis pointing mirror.</td>
</tr>
<tr>
<td>Developmental Status</td>
<td>Under development for AAFE program (1970)</td>
</tr>
</tbody>
</table>

### Performance Characteristics

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>2000 - 3000 Å</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>2 Å</td>
</tr>
<tr>
<td>Field of View</td>
<td>1 - 3 degrees</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>17 - 50 km</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>15-bit data resolution</td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

### Physical Characteristics

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Sounder</th>
<th>Gimbal &amp; Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size cm. (in.)</td>
<td>36 dia. x 66 (14.2 dia. x 26)</td>
<td>Integral with Sounder</td>
</tr>
<tr>
<td>Weight Kg (lb)</td>
<td>6.8 (15)</td>
<td>4.5 (10)</td>
</tr>
<tr>
<td>Power W.</td>
<td>15</td>
<td>10 pk., 5 av.</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
<td>0.1 degree</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>10 arc-min/sec</td>
</tr>
<tr>
<td>Data Output</td>
<td>1.6 kbps</td>
</tr>
</tbody>
</table>

### Comments:

Dr. Charles Barth (University of Colorado) Principal Investigator. Considerable flexibility in operating modes and data rates.
**SENSOR: VISIBLE RADIATION POLARIMETER (VRP)**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Measurement of the intensity and polarization of the sunlit atmosphere and terrain in several spectral bands.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Optical system, spectral filters, polarizing filters, silicon detectors.</td>
</tr>
<tr>
<td>Configuration</td>
<td>State-of-the-art instrument. Development for space flight required.</td>
</tr>
<tr>
<td>Major Elements</td>
<td></td>
</tr>
<tr>
<td>Developmental Status</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th>O2, Sea Ice Mapping</th>
<th>M1 - Noctilucent Clouds</th>
<th>M4 Air Pollution &amp; Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range (µ)</td>
<td>0.55</td>
<td>0.46, 0.55, 0.57</td>
<td>0.38, 0.44, 0.50, 0.58</td>
</tr>
<tr>
<td>Spectral Resolution (Å)</td>
<td>3000</td>
<td>300, 3000, 300</td>
<td>100</td>
</tr>
<tr>
<td>Field of View (deg.)</td>
<td>3</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>Spatial Resolution Km(n, mi)</td>
<td>18.5(10)</td>
<td>1.9 (1)</td>
<td>18.5 (10)</td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Field of View</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Wavelength Range (µ)</td>
<td>0.55</td>
<td>0.46, 0.55, 0.57</td>
<td>0.38, 0.44, 0.50, 0.58</td>
</tr>
<tr>
<td>Spectral Resolution (Å)</td>
<td>3000</td>
<td>300, 3000, 300</td>
<td>100</td>
</tr>
<tr>
<td>Field of View (deg.)</td>
<td>3</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>Spatial Resolution Km(n, mi)</td>
<td>18.5(10)</td>
<td>1.9 (1)</td>
<td>18.5 (10)</td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size cm. (in.)</td>
</tr>
<tr>
<td>Weight Kg (lbs)</td>
</tr>
<tr>
<td>Power W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
</tr>
<tr>
<td>Data Output</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique under study at UCLA for measurement of particulate air pollution</td>
</tr>
</tbody>
</table>

* From orbital altitude of 370 Km (200 n, mi.)
**INSTRUMENT SPECIFICATION No. 21**

**SENSOR: AIR POLLUTION CORRELATION SPECTROMETER**

<table>
<thead>
<tr>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td><strong>Configuration, Major Elements</strong></td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength Range</strong></td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
</tr>
<tr>
<td><strong>Power</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pointing Accuracy</strong></td>
</tr>
<tr>
<td><strong>Line of Sight Rate (max.)</strong></td>
</tr>
<tr>
<td><strong>Data Output</strong></td>
</tr>
</tbody>
</table>

| Comments: | Configuration developed by Barringer Research Ltd. |
# SENSOR: HIGH SPEED INTERFEROMETER (HSI)

<table>
<thead>
<tr>
<th>General Description</th>
<th>Measurement of total amount and vertical distribution of atmospheric pollutants: CO, CO₂, NO, HCl, O₃, NO₂, SO₂, NH₃, C₂H₂, C₂H₄, CH₃OH.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Michelson Interferometer - Optics, Chopper, HeNe laser with PMT, interferometer, pyroelectric detectors (uncooled), reference blackbody source.</td>
</tr>
<tr>
<td>Configuration, Major Elements</td>
<td>Breadboard model flown in blimp tests (AAFE &amp; OMSF funding)</td>
</tr>
<tr>
<td>Development Status</td>
<td>Breadboard model flown in blimp tests (AAFE &amp; OMSF funding)</td>
</tr>
</tbody>
</table>

## Performance Characteristics

<table>
<thead>
<tr>
<th>Wavelength Range</th>
<th>1.2 to 8 μ (downlooking); 200 cm⁻¹ (pointing at earth limb and sun)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Resolution</td>
<td>0.10 cm⁻¹ (max.)</td>
</tr>
<tr>
<td>Field of View (IFOV)</td>
<td>1.25° (earth-pointing), 0.25° (earth limb-pointing)</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>1.25°, 7.8 km (4.2 n. mi.) at 370 km altitude</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>5 to 500 PPB/Km (dependent upon species)</td>
</tr>
<tr>
<td>Pointing Requirements</td>
<td>5° from nadir (two axes); point to sun at earth limb</td>
</tr>
</tbody>
</table>

## Physical Characteristics

<table>
<thead>
<tr>
<th>Size cm (in.)</th>
<th>Interferometer: 25 x 60 x 75 (10 x 24 x 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Kg (lbs.)</td>
<td>23 (50)</td>
</tr>
<tr>
<td>Power W</td>
<td>150</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gimbal &amp; Control (2)</th>
<th>32 x 51 x 80 (12.6 x 20 x 31.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Kg (lbs.)</td>
<td>23 (50)</td>
</tr>
<tr>
<td>Power W</td>
<td>130 pk/45 av.</td>
</tr>
</tbody>
</table>

## Platform/Data Considerations

<table>
<thead>
<tr>
<th>Pointing Accuracy</th>
<th>0.25 deg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>0.25 deg. stability during 3 min. or 15 sec. scan (target tracking)</td>
</tr>
<tr>
<td>Data Output</td>
<td>14 bits + 1 parity bit/data point, 20 KB/S max. 65, 536 data points/spectrum, 0.983 MB total.</td>
</tr>
</tbody>
</table>

## Comments:

3 min. /spectral scan (down-looking), 15 sec. /scan (solar pointing). Slave to tracking telescope for target tracking. Two-axis gimbal and rate gyro stabilization required.

(1) Preliminary Estimates
(2) Gimbal system used for both Instrument No. 22 and Instrument No. 23.
### SENSOR: CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)\(^{(1)}\)

| General Description | 1. Mapping of global concentration of atmospheric pollutants.  
| Configuration, Major Elements | 3. Measures CO, CO\(_2\), SO\(_2\), H\(_2\)O, NH\(_4\), NO, N\(_2\)O, NO\(_2\) concentr.  
| Developmental Status | Michelson type correlation interferometer.  
| Performance Characteristics | Initial funding under AAFE program. Further work funded by General Electric Company.  
| Wavelength Range | Either 1 to 3 or 3 to 5 micron spectral range (PbS or PbSe)  
| Spectral Resolution | Optical correlation of very fine spectral lines  
| Field of View | 2 deg. (mapping mode), (2) 0.1 deg. (limb viewing-sun-oriented)  
| Spatial Resolution | 12.6 Km (6.8 n.mi.) from 370 Km (200 n.mi.) altitude  
| Sensitivity | Depends upon pollutant being measured.  
| Physical Characteristics | Interferometer | Gimbals & Control  
| Size | 26 x 30 x 74 (11 x 22 x 29) | See Instrument No. 22  
| Weight | 21 (45) |  
| Power | 20 av./35 pk. |  
| Platform/Data Considerations | Pointing Accuracy | 0.5 deg. (earth-mapping), 0.05 deg. (solar pointing)  
| Line of Sight Rate (max.) | 2 deg./min. |  
| Data Output | 1.2 KB/S (serial), 6 x 10\(^6\) bits/orbit (continuous data), 15-bit encoding. |  
| Comments: | Detector cooled by Peltier cooler to 195 K\(^\circ\). In 3 - 5\(\mu\) range, requires correlative data on atmospheric temp. profile.  

Notes: 1. Current acronym is CIMATS (Correlation Interferometric Measurement of Atmospheric Trace Species).  
2. Views nadir only, cross-track scan not used.
## INSTRUMENT SPECIFICATION No. 24
### SENSOR: CLOUD PHYSICS RADIOMETER (CPR)

**General Description**
- To measure reflected solar radiation from clouds in five spectral bands to obtain data from which may be inferred: a) cloud top pressure level, b) density and phase of condensed water in clouds, c) a drop size parameter, d) optical and geometric thickness of clouds.

**Configuration, Major Elements**
- Rotating scan mirror, grating spectrometer, two PMT detectors, and three InAs detectors cooled to 120 K (or three uncooled PbS detectors).

**Developmental Status**
- Currently in preliminary design status.

### Performance Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Visible Window</th>
<th>O₂ Absorption Band</th>
<th>CO₂ Absorption Band</th>
<th>IR Window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice vs Liquid Thickness</td>
<td>0.754</td>
<td>0.763</td>
<td>1.61</td>
<td>2.06</td>
</tr>
<tr>
<td>Liquid thickness</td>
<td>0.005</td>
<td>0.005</td>
<td>0.072</td>
<td>0.050</td>
</tr>
<tr>
<td>Wavelength Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field of View</td>
<td>Transverse scan ±1° from nadir</td>
<td>IFOV 2.5 mRad.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>(0.5 n.mi.) 0.92 km from altitude of 370 km (200 n.mi.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (NEΔp)</td>
<td>Not Specified</td>
<td>0.014%</td>
<td>0.04%</td>
<td>0.06%</td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>2% (0.1 percent relative for all channels)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Radiometer</th>
<th>V-M Cooler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (cm, in.)</td>
<td>25.4 x 25.4 x 86 (10 x 10 x 33.8)</td>
<td>Included in Radiometer</td>
</tr>
<tr>
<td>Weight (Kg, lb)</td>
<td>32 (70)</td>
<td>3.6 (8)</td>
</tr>
<tr>
<td>Power (W)</td>
<td>40</td>
<td>45</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

- 1 degree Pointing Accuracy
- Line of Sight Rate (max.) 0.5 mrad/sec
- Data Output 0.64 Mbps (without buffer) / 0.33 Mbps (buffered), 10-bit encoding

**Comments:**
- Correlative meteorological data from aircraft is required.
## SENSOR: REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)

### General Description
- **Function:** Global night and day meas. of tropospheric pollutants. Meas. of upper atmos. pollutant concentrations. Will meas. concentrations from 0.001 to 350 ppm of CO, CO₂, NO, NO₂, NH₃, and CH₄ in spectral regions from 2 to 20 microns.
- **Configuration, Major Elements:** Objective lens, collimating optics, selective gas filters, IR detectors, closed cycle cooler (77 K).
- **Developmental Status:** Aircraft flight model under development by Science Applications, Inc, for AAFE Program.

### Performance Characteristics
- **Wavelength Range:** 2 to 20 µ (CO - 4.6 µ) (SO₂ - 7.4 and 8.7 µ) (NO₂ - 10 µ)
  - NO - 5.4 µ (NH₃ - 10.5 µ) are possibilities.
- **Spectral Resolution:** Fine resolution, dependent upon spectra of gases.
- **Field of View:** 5 deg. Scans laterally over an angle of 36.8 deg. at a rate of 1.6 deg/sec.
- **Spatial Resolution:** 50 n. mi. from 600 n. mi. orbital altitude.
- **Sensitivity:** 0.001 to 350 ppm.
- **Absolute Accuracy:** Better than 1 percent.

### Physical Characteristics
- **Correlation Analyzer:** 28 x 34 x 106 (11 x 13.4 x 41.7) cm. (in.)
- **Electronics:** 20 x 30 x 30 (7.9 x 11.8 x 11.8) cm.
- **Size (cm. (in.)):**
  - 28 x 34 x 106 (11 x 13.4 x 41.7)
  - 20 x 30 x 30 (7.9 x 11.8 x 11.8)
- **Weight (Kg (lb)):**
  - 14 (30)
  - 9 (20)
- **Power:** 7 watts average, 10 watts peak.

### Platform/Data Considerations
- **Pointing Accuracy:** 2 deg. in all axes (viewing nadir); 0.1 deg. (sun occultation tracking).
- **Line of Sight Rate (max.):** 1 m/sec.
- **Data Output:** <0.4 Kb/s.

### Comments:
## INSTRUMENT SPECIFICATION No. 26

### SENSOR: ADVANCED LIMB RADIANCE INVERSION RADIOMETER (ALRIR) \(^{(1)}\)

<table>
<thead>
<tr>
<th>General Description</th>
<th>Determination of the vertical distribution of temperature, ozone, water vapor, oxides of nitrogen, nitric acid, methane, and sulfate aerosols from the upper troposphere to the mesosphere.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Radiometer, attitude reference unit, interface electronics unit, scanning mirror, telescope, 10 HgCdTe detectors, Vuilleumier cooler, electronics, blackbody calibration source.</td>
</tr>
<tr>
<td>Development Status</td>
<td>Currently in development under AAFE funding by Honeywell Aerospace Division for balloon flight tests.</td>
</tr>
</tbody>
</table>

### Performance Characteristics \(^{(2)}\)

<table>
<thead>
<tr>
<th>Wavelength Range (microns)</th>
<th>(\text{NO}_2)</th>
<th>(\text{H}_2\text{O})</th>
<th>(\text{CH}_4)</th>
<th>(\text{O}_3)</th>
<th>(\text{Sulf.})</th>
<th>(\text{HNO}_3)</th>
<th>(\text{CO}_2)</th>
<th>(\text{N}_2\text{O})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6.2)</td>
<td>(6.3)</td>
<td>(7.8)</td>
<td>(9.6)</td>
<td>(10.8)</td>
<td>(11.3)</td>
<td>(15)</td>
<td>(17)</td>
<td>(17.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field of View (mRad.)</th>
<th>N/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Resolution</td>
<td>1x2.5</td>
</tr>
<tr>
<td>Spatial Resolution (Km)</td>
<td>4x10</td>
</tr>
<tr>
<td>Sensitivity (w/m^2 - ster.) (Noise Eq. Radiance)</td>
<td>N/S</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Radiometer</th>
<th>V-M Cooler</th>
<th>Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (cm, in.)</td>
<td>37 x 49 x 116 (14.6 x 18.5 x 62.5)</td>
<td>(\ast) 20 x 30 x 30 (8 x 12 x 12)</td>
<td>13.6 (30)</td>
</tr>
<tr>
<td>Weight (Kg, lb.)</td>
<td>18 (40)</td>
<td>3.6 (8)</td>
<td>45</td>
</tr>
<tr>
<td>Power (W)</td>
<td>40 pk. /20 av.</td>
<td>(\ast) incl. in radiometer</td>
<td>40 pk. /30 av.</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

<table>
<thead>
<tr>
<th>Pointing Accuracy</th>
<th>0.1 degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line of Sight Rate</td>
<td>LOS rate must be measured using rate gyro to accuracy of (\pm 0.0014) degrees during 4 sec. vertical scan (1 deg./hr rate).</td>
</tr>
<tr>
<td>Data Output</td>
<td>4.0 Kb/sec.</td>
</tr>
</tbody>
</table>

### Comments:

P.I. — Dr. John C. Gille, NCAR

---

\(^{(1)}\) Current acronym is LACATE, Lower Atmosphere Composition and Temperature Experiment.

\(^{(2)}\) Two additional channels are used for atmos. temp. measurement.
## INSTRUMENT SPECIFICATION No. 27

**SENSOR:** TIROS N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

<table>
<thead>
<tr>
<th><strong>General Description</strong></th>
<th><strong>Function</strong></th>
<th><strong>Configuration, Major Elements</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Description</strong></td>
<td>To obtain high resolution imagery of cloud cover and measurements of terrain and ocean temperature as supporting data for Remote Gas Filter Correlation Analyzer</td>
<td>Scanning mirror, telescope, beam splitters, optical filters, relay lenses, silicon diodes or PMT's, HgCdTe detectors, passive radiative cooler (or closed-cycle V-M cooler).</td>
</tr>
<tr>
<td><strong>Developmental Status</strong></td>
<td>In development for TIROS-N</td>
<td></td>
</tr>
</tbody>
</table>

### Performance Characteristics

<table>
<thead>
<tr>
<th><strong>Performance Characteristics</strong></th>
<th><strong>Wavelength Range</strong></th>
<th><strong>Spectral Resolution</strong></th>
<th><strong>Field of View</strong></th>
<th><strong>Spatial Resolution</strong></th>
<th><strong>Sensitivity</strong></th>
<th><strong>Absolute Accuracy</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 - 0.7 µm</td>
<td>0.25 µm</td>
<td>Transverse line scan 455° (1) -76° (2) from nadir (rotary scan)</td>
<td>1 km (0.55 mr)</td>
<td>NEΔρ 0.01</td>
<td>Not specified</td>
</tr>
<tr>
<td></td>
<td>0.75-1.0 µm</td>
<td>0.5 µm</td>
<td></td>
<td>1 km (0.55 mr)</td>
<td>NEΔρ 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.5-7.0 µm</td>
<td>2.0 µm</td>
<td></td>
<td>1 km (0.55 mr)</td>
<td>1°K at 200°K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.5-12.5 µm</td>
<td></td>
<td></td>
<td>4 km(2.2 mr)</td>
<td>5°K at 300°K</td>
<td></td>
</tr>
<tr>
<td><strong>Cloud Mapping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Terrain Mapping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Atmospheric Water Vapor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cirrus Clouds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Surface Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Characteristics

<table>
<thead>
<tr>
<th><strong>Physical Characteristics</strong></th>
<th><strong>Radiometer</strong></th>
<th><strong>V-M Cooler</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size cm. (in.)</strong></td>
<td>28 x 28 x 106 (11 x 11 x 41.7)</td>
<td>Included in Radiometer</td>
</tr>
<tr>
<td><strong>Weight Kg (lb)</strong></td>
<td>16 (35)</td>
<td>3.6 (8)</td>
</tr>
<tr>
<td><strong>Power W</strong></td>
<td>25</td>
<td>45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Platform/Data Considerations</strong></th>
<th><strong>Pointing Accuracy</strong></th>
<th><strong>Line of Sight Rate (max.)</strong></th>
<th><strong>Data Output</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1 degree</td>
<td>0.4 mR/sec</td>
<td>1.12 MB/S (8-bit encoding)</td>
</tr>
</tbody>
</table>

| **Comments:** | Passive radiation cooling or closed-cycle Vuilleumier cooler required for Channels 3 and 4 to obtain detector temperature of 90°K. |

(1) Toward the sun, (2) Away from sun.
## SENSOR: TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)

### General Description

**Function**
- a. Atmos. temperature profiling (surface to 1 mb)
- b. Atmos. water vapor profiling (surface to tropopause)
- c. Determination of total amount of atmos. ozone (0.15 - 0.6 cm)

**Configuration, Major Elements**
- Optical systems (4 packages), cooled PbSe detector, TGS pyro-electric detectors, CO₂ cells, optical choppers, two-channel Dicke-type microwave radiometer

**Developmental Status**
- Under study for use on TIROS-N

### Performance Characteristics

<table>
<thead>
<tr>
<th></th>
<th>OPA</th>
<th>OPB</th>
<th>OPC</th>
<th>OPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>3.70-4.54µ (6 bands)</td>
<td>9.7-29.41µ (10 bands)</td>
<td>14.97µ (1 band)</td>
<td>53.34 and 53.88 GHz</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>25 - 35 cm⁻¹</td>
<td>15 - 25 cm⁻¹</td>
<td>1.3 cm⁻¹</td>
<td>220 MHz</td>
</tr>
<tr>
<td>Field of View</td>
<td>±40 degrees scan (cross-track)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>1 degree</td>
<td>1 degree</td>
<td>10 degrees</td>
<td>10 degrees</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>175 to 300 K deg. (temp); 0.0001 to 30 g/Kg (water vapor), 0.15 - 0.50 cm (ozone)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Accuracy</td>
<td>±1 deg. K (temp.); 10 percent (water vapor); ±0.01 cm (ozone)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>OPA</th>
<th>OPB</th>
<th>OPC</th>
<th>OPD</th>
<th>Elect.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size cm.</td>
<td>20 D x 31</td>
<td>25 x 51 x 51</td>
<td>18 D x 25</td>
<td>10 x 15 x 31</td>
<td>20 x 20 x 33</td>
<td></td>
</tr>
<tr>
<td>Weight Kg (lb)</td>
<td>45 (99)</td>
<td>5.5 (12)</td>
<td>13.5 (30)</td>
<td>4.5 (10)</td>
<td>9 x (20)</td>
<td>10 (22)</td>
</tr>
<tr>
<td>Power W</td>
<td>73</td>
<td>10</td>
<td>18</td>
<td>5</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

### Platform/Data Considerations

- **Pointing Accuracy**: 0.5 deg.
- **Line of Sight Rate (max.)**: 0.05 deg/sec
- **Data Output**: 3 Kb/s

### Comments:
- P.I. D. Wark, NOAA
- (1) Includes Peltier Cooler for OPA Detector, 2.3 Kg. (5 lb.), 10 W.
### INSTRUMENT SPECIFICATION No. 29

**SENSOR:** PASSIVE MULTICHANNEL MICROWAVE RADIOMETER (PMMR)

<table>
<thead>
<tr>
<th>General Description</th>
<th>Precipitation survey, establish sea surface roughness and wind, measure sea surface temperatures.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Five conically scanned V and H polarization antennas, V and H receiver for each band, switch and scanning electronics and temperature references.</td>
</tr>
<tr>
<td><strong>Configuration,</strong></td>
<td>Development required. Similar to scanning microwave radiometer being developed for Nimbus F.</td>
</tr>
<tr>
<td><strong>Major Elements</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Development Status</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Performance Characteristics**

- **Wavelength Range:** 4.99, 10.69, 18, 21.5, 37 GHz
- **Spectral Resolution:** 200 MHz predetection bandwidth
- **Field of View:** Antenna beamwidth (4.99 GHz) is 10.6 degrees, 5.3 degrees for the three mid-wavelengths, and 1.3 degrees for the 37 GHz band
- **Spatial Resolution:** 67, 33, 33, 33, 8.4 Km (from 370 Km orbital altitude)
- **Sensitivity:** 0.5 deg. K
- **Absolute Accuracy:** 1.5 deg. K

**Physical Characteristics**

<table>
<thead>
<tr>
<th>Band (GHz)</th>
<th>4.99</th>
<th>10.69</th>
<th>18.00</th>
<th>21.50</th>
<th>37.00</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size, Antenna $m^2$ $(ft^2)$</td>
<td>1.60(17.2)</td>
<td>1.30(14.0)</td>
<td>0.50(5.4)</td>
<td>0.35(3.8)</td>
<td>1.70(18.3)</td>
<td>5.45(58.5)</td>
</tr>
<tr>
<td>Weight Kg (lb) $^{(1)}$</td>
<td>69(155)</td>
<td>48(107)</td>
<td>30(68)</td>
<td>25(55)</td>
<td>57(128)</td>
<td>230(513)</td>
</tr>
<tr>
<td>Power Watts $^{(1)}$</td>
<td>90</td>
<td>80</td>
<td>50</td>
<td>40</td>
<td>95</td>
<td>355</td>
</tr>
</tbody>
</table>

$^{(1)}$ Specifications include receivers and power supply.

**Platform/Data Considerations**

- **Pointing Accuracy:** 1.0 deg.
- **Line of Sight Rate (max.):** 1.0 deg/sec
- **Data Output:** ~200 bps (10-bit encoding)

**Comments:** Use conical sector scanning. Half-cone angle 45 deg. from nadir. Sector scan angle +25 deg. about nadir. 325 km (177 n. mi.) swath width from 370 km (200 n. mi.) altitude. 10 measurements/scan.
**SENSOR: MICROWAVE RADIOMETER/SCATTEROMETER**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Measurement of sea surface roughness, altimetry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration, Major Elements</td>
<td>Similar to Skylab S193 with higher resolution. Antenna similar to Planar Array being developed for Nimbus F.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>37 GHz</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>300 MHz bandwidth</td>
</tr>
<tr>
<td>Field of View (IFOV)</td>
<td>2.6 m Rad., trainable (See Comments)</td>
</tr>
<tr>
<td>Spatial Resolution Km(n.m.)</td>
<td>0.96 (0.52) from 370 Km (200 n.m.) altitude</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1 Beaufort No. - Surface Roughness, 0.5°K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Antenna</th>
<th>Transmtr/Recvr.</th>
<th>Gimbal &amp; Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size cm. (in.)</td>
<td>300x300x15 (118x118x6)</td>
<td>30x30x60 (12x12x24)</td>
<td>254x30x30 (100x12x12)</td>
</tr>
<tr>
<td>Weight Kg (lb)</td>
<td>346 (760)</td>
<td>23 (50)</td>
<td>91 (200)</td>
</tr>
<tr>
<td>Power W</td>
<td>217</td>
<td>50(T_x) /30 R_x</td>
<td>500 pk /200 av.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform/Data Considerations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing Accuracy</td>
<td>1 degree</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>0.06 mr/sec</td>
</tr>
<tr>
<td>Data Output</td>
<td>80 BPS</td>
</tr>
</tbody>
</table>

**Comments:**
Electronic scanning (one axis) ±35 deg. normal to array. Array mechanically pointable ±70 deg. in pitch.
### INSTRUMENT SPECIFICATION No. 31

**SENSOR: SFERICS RECEIVER**

<table>
<thead>
<tr>
<th>General Description</th>
<th>Detection of electromagnetic emission in the radio frequency range (sferies) from the atmosphere in areas of thunderstorm activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Three antennas, amplifiers, and receiver/signal processors.</td>
</tr>
<tr>
<td>Development Status</td>
<td>State of the art. Development for space flight required.</td>
</tr>
<tr>
<td></td>
<td><strong>Performance Characteristics</strong></td>
</tr>
<tr>
<td>HF</td>
<td>VHF</td>
</tr>
<tr>
<td>Wavelength Range</td>
<td>6 - 20 MHz (variable)</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>1 KHz</td>
</tr>
<tr>
<td>Field of View</td>
<td>~90 deg.</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>740 Km</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>S/N &gt;20 dB</td>
</tr>
<tr>
<td></td>
<td><strong>Physical Characteristics</strong></td>
</tr>
<tr>
<td>Size</td>
<td>0.017 (0.58)</td>
</tr>
<tr>
<td>Weight</td>
<td>10 (22)</td>
</tr>
<tr>
<td>Power</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>(1) Includes antennas, amplifiers, and receiver/signal processors</td>
</tr>
<tr>
<td></td>
<td><strong>Platform/Data Considerations</strong></td>
</tr>
<tr>
<td>Pointing Accuracy</td>
<td>5 degree</td>
</tr>
<tr>
<td>Line of Sight Rate</td>
<td>0.5 deg./sec.</td>
</tr>
<tr>
<td>Data Output</td>
<td>260 B/S</td>
</tr>
<tr>
<td></td>
<td>(observation period = 20 to 30 min.)</td>
</tr>
<tr>
<td>Comments:</td>
<td>Cavity-backed planar spiral antennas at 300 and 610 MHz. Half-wave dipole, 20 m. length, for 6 - 20 MHz band. All antennas fixed and pointed to the nadir.</td>
</tr>
</tbody>
</table>
**INSTRUMENT SPECIFICATION No. 32**

**SENSOR: WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Description</strong></td>
<td>Visual observation of lightning flashes associated with electromagnetic emissions (sferics) from the atmosphere in areas of thunderstorm activity. Optical viewfinder, similar to Wild NF2 navigation sight, with removable narrow-band spectral filter and TV camera. Operational in aircraft. Development for space flight required.</td>
</tr>
<tr>
<td><strong>Performance Characteristics</strong></td>
<td>(Daytime) 6563 Å, (Night time) 0.4 - 0.7µ (Daytime) 50 Å, (Night time) 0.3µ 110°/55°/28° square, 0.5/1.0/2.0 x magnification 360° azimuth view capability. Gimbaled, 0 to 60° from Nadir.</td>
</tr>
<tr>
<td><strong>Physical Characteristics</strong></td>
<td>Viewer</td>
</tr>
<tr>
<td>Size (Cm. (in.))</td>
<td>25.7 x 32.0 x 127.0</td>
</tr>
<tr>
<td>Weight (Kg. (lb.))</td>
<td>25 (55)</td>
</tr>
<tr>
<td>Power (W)</td>
<td>10 (reticle illumination)</td>
</tr>
<tr>
<td><strong>Platform/Data Considerations</strong></td>
<td>2 degrees</td>
</tr>
<tr>
<td>Line of Sight Rate (max.)</td>
<td>N/A - Visual Observation</td>
</tr>
<tr>
<td>Data Output</td>
<td></td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td>Can be used as general-purpose wide-angle viewer for all experiments.</td>
</tr>
</tbody>
</table>
## General Description

### Function
- Collection and relay of data from mobile and surface platforms in free-floating buoys & balloons and in fixed surface locations.
- Determination of platform location

### Configuration, Major Elements
- Antenna, receiver, multiple-track tape recorder, and S-band transmitter

### Developmental Status
- Phase A system study completed for application to TIROS-N satellite

## Performance Characteristics

### Wavelength Range
- 400 MHz uplink from platforms. S-band downlink from spacecraft.

### Spectral Resolution
- Not applicable.

### Field of View
- Receiver antenna gain = 2.5 2.5 dB; transmitter ant. gain = 1 to 2 dB

### Spatial Resolution
- Not applicable.

### Sensitivity
- Receiver noise figure 3 dB, signal level -154.4 to -163.3 dBw

### Absolute Accuracy
- Accuracy of sensor data = 1 percent

## Physical Characteristics

<table>
<thead>
<tr>
<th>Size</th>
<th>Receiver</th>
<th>Mx</th>
<th>Rcdr. Transport</th>
<th>Rcdr. Elect</th>
<th>Transmitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm.</td>
<td>5x15x15</td>
<td>5x15x15</td>
<td>36 dia. x 15</td>
<td>13x15x25</td>
<td>15x20x33</td>
</tr>
<tr>
<td>Weight</td>
<td>1.4 (3)</td>
<td>1.4 (3)</td>
<td>6.4 (14)</td>
<td>2.3 (5)</td>
<td>2.7 (6)</td>
</tr>
<tr>
<td>Power W</td>
<td>2</td>
<td>2</td>
<td>-8</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

## Platform/Data Considerations

### Pointing Accuracy
- Not critical

### Line of Sight Rate (max.)
- Not critical

### Data Output
- Data recording time 240 min at 30 kHz/each of 5 tracks.
- Data transfer time six minutes at 240 KHz.

## Comments:
- Data storage capacity: Two orbits (1000 platforms per orbit).
- Direct recording on multiple-track tape recorder.

*Configuration based upon Random Access Measurement System (RAMS) under study for TIROS-N Satellite.*
APPENDIX B

EXPERIMENT INPUTS TO OTO AND PACER
COMPUTER PROGRAMS
APPENDIX B

EXPERIMENT INPUTS TO OTO AND PACER COMPUTER PROGRAMS

In order to select an orbit for a reference mission, each mission experiment must be considered in terms of:

- Target size and location
- Observation frequency
- Observation altitude
- Illumination constraints
- Optimization requirement

This Appendix defines each Level 1 experiment by specifying the requirements associated with the items mentioned above.

These requirements are used in the orbital optimization programs:

- (OTO) orbit track optimization
- (PACER) percent area coverage, earth resources

OTO is used if frequency of coverage is to be maximized and PACER is used if the percent of target area coverage is to be maximized.
**Discipline:** Agriculture, Forestry, Rangelands  

**Experiment No. and Title:** AFR1 - International Agricultural Station Monitoring Program

---

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Manhattan, Kansas</td>
<td>39°11'N</td>
<td>96°34'W</td>
</tr>
<tr>
<td>2. Columbia, Mo.</td>
<td>36°55'N</td>
<td>92°19'W</td>
</tr>
<tr>
<td>3. Lincoln, Nebraska</td>
<td>40°49'N</td>
<td>96°43'W</td>
</tr>
<tr>
<td>4. Sioux Falls, S. Dak.</td>
<td>43°33'N</td>
<td>96°43'W</td>
</tr>
<tr>
<td>5. Bismark, N. Dak.</td>
<td>46°48'N</td>
<td>100°46'W</td>
</tr>
<tr>
<td>6. Riverside, Calif.</td>
<td>33°59'N</td>
<td>119°21'W</td>
</tr>
<tr>
<td>7. Salem, Oregon</td>
<td>44°55'N</td>
<td>123°03'W</td>
</tr>
<tr>
<td>8. Madison, Wis.</td>
<td>43°05'N</td>
<td>89°23'W</td>
</tr>
<tr>
<td>9. Ames, Iowa</td>
<td>42°00'N</td>
<td>93°36'W</td>
</tr>
<tr>
<td>10. Bowling Green, Ky.</td>
<td>37°00'N</td>
<td>86°26'W</td>
</tr>
<tr>
<td>11. Truth or Consequences, N.M.</td>
<td>33°10'N</td>
<td>107°20'W</td>
</tr>
<tr>
<td>12. Champaign-Urbana, Ill.</td>
<td>40°10'N</td>
<td>88°15'W</td>
</tr>
<tr>
<td>13. W. Lafayette, Ind.</td>
<td>40°25'N</td>
<td>86°55'W</td>
</tr>
<tr>
<td>14. Waltbury, Ct.</td>
<td>41°30'N</td>
<td>73°00'W</td>
</tr>
<tr>
<td>15. Baltimore, Md.</td>
<td>39°05'N</td>
<td>76°40'W</td>
</tr>
<tr>
<td>16. Foyang, China</td>
<td>32°53'N</td>
<td>115°48'E</td>
</tr>
<tr>
<td>17. Tang fon, China</td>
<td>32°54'N</td>
<td>117°22'E</td>
</tr>
<tr>
<td>18. Chiang-Tu, China</td>
<td>32°24'N</td>
<td>119°24'E</td>
</tr>
<tr>
<td>19. Tung T'ai, China</td>
<td>32°50'N</td>
<td>120°16'E</td>
</tr>
<tr>
<td>20. Lini, China</td>
<td>35°04'N</td>
<td>118°21'E</td>
</tr>
<tr>
<td>21. Nan Cling, China</td>
<td>26°40'N</td>
<td>118°05'E</td>
</tr>
<tr>
<td>22. Ube, Japan</td>
<td>33°07'</td>
<td>131°18'E</td>
</tr>
<tr>
<td>23. Nemuro, Japan</td>
<td>43°13'N</td>
<td>145°10'E</td>
</tr>
<tr>
<td>24. Chittagong, Bangladesh</td>
<td>22°26'N</td>
<td>90°51'E</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/#Days) —**

- **Desirable:** 2/5  
  - **Acceptable:** 1/5

**Altitude (n. mi.) —**

- **Desirable:** 100-150  
  - **Acceptable:** 150-300

**Illumination Constraints —**

- Solar Elev. Angle (deg.): ≥30  
  - Time of Year: All Months

**Target Location —**

- F.O.V. (deg.): 9.5  
  - Off-Nadir Pointing (deg.): ±26.5

**Optimization —**

- Mapping:  
  - Target Pass: X

**Comments —**

16 targets required from list, as follows:

- Any 6 from targets 1 - 15,  
- Any 3 from targets 16 - 23,  
- Any 2 from targets 24 - 28,  
- Any 1 from targets 29 - 31,  
- Any 4 from targets 32 - 42.

*March-September most desirable.*

(continued)
DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFRI - INTERNATIONAL AGRICULTURAL STATION MONITORING PROGRAM

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Dacca, Bangladesh</td>
<td>23°45'N</td>
<td>90°29'E</td>
</tr>
<tr>
<td>26. Ranchi, India</td>
<td>23°24'N</td>
<td>85°18'E</td>
</tr>
<tr>
<td>27. Kandy, Ceylon</td>
<td>7°18'N</td>
<td>80°42'E</td>
</tr>
<tr>
<td>28. Bassein, Burma</td>
<td>16°46'N</td>
<td>94°47'E</td>
</tr>
<tr>
<td>29. Damietta, U.A.R.</td>
<td>31°22'N</td>
<td>31°50'E</td>
</tr>
<tr>
<td>30. Nicosia, Cyprus</td>
<td>35°10'N</td>
<td>33°22'E</td>
</tr>
<tr>
<td>31. Baghari, Algeria</td>
<td>35°50'N</td>
<td>2°48'E</td>
</tr>
<tr>
<td>32. Mersing, Malaysia</td>
<td>2°25'N</td>
<td>103°51'E</td>
</tr>
<tr>
<td>33. Goomo Goomo, Australia</td>
<td>31°25'S</td>
<td>150°44'E</td>
</tr>
<tr>
<td>34. Wagga-Wagga, Australia</td>
<td>35°10'S</td>
<td>147°30'E</td>
</tr>
<tr>
<td>35. Brewarrina, Australia</td>
<td>29°54'S</td>
<td>146°50'E</td>
</tr>
<tr>
<td>36. Thargomindah, Australia</td>
<td>27°58'S</td>
<td>142°57'E</td>
</tr>
<tr>
<td>37. Katherine, Australia</td>
<td>14°15'S</td>
<td>132°20'E</td>
</tr>
<tr>
<td>38. Esperance, Australia</td>
<td>33°45'S</td>
<td>122°07'E</td>
</tr>
<tr>
<td>39. Nomalup, Australia</td>
<td>35°00'S</td>
<td>117°00'E</td>
</tr>
<tr>
<td>40. Ingham, Australia</td>
<td>18°45'S</td>
<td>146°14'E</td>
</tr>
<tr>
<td>41. Burnie, Tasmania</td>
<td>41°15'S</td>
<td>146°05'E</td>
</tr>
<tr>
<td>42. U. of Sydney, Badgery-S. Creek, Australia</td>
<td>34°05'S</td>
<td>150°35'E</td>
</tr>
</tbody>
</table>
DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

EXPERIMENT NO. AND TITLE: AFR2 - MULTISTAGE SAMPLING OF VEGETATION RESOURCES

<table>
<thead>
<tr>
<th>TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and Name</td>
</tr>
<tr>
<td>1. Bootheel of Missouri</td>
</tr>
<tr>
<td>2. Central Valley of Calif.</td>
</tr>
<tr>
<td>3. Yellowstone Nat'l Park</td>
</tr>
<tr>
<td>4. Lower Cape York Peninsula</td>
</tr>
<tr>
<td>5. Central Highlands, N. Guinea</td>
</tr>
<tr>
<td>6. Alajuela Prov., Costa Rica</td>
</tr>
<tr>
<td>7. Cordillera Central, P.R.</td>
</tr>
<tr>
<td>8. Serra dos Carajás, Brazil</td>
</tr>
<tr>
<td>9. Lambarene, Gabon</td>
</tr>
<tr>
<td>10. Kano, Nigeria</td>
</tr>
<tr>
<td>11. Between Teheran &amp; Caspian Sea</td>
</tr>
<tr>
<td>12. Menako, N. Celebes</td>
</tr>
</tbody>
</table>

Observational Frequency (#Looks/#Days) —
Desirable: 2/5
Acceptable: 1/5

Altitude (in. mi.) —
Desirable: 100-150
Acceptable: 150-300

Illumination Constraints —
Solar Elev. Angle (deg.): ≥30
Time of Year: All Seasons

Target Location —
F. O. V. (deg.): 9.5
Off-Nadir Pointing (deg.): ±26.5

Optimization —
Mapping:
Target Pass: X

Comments —
Any 5 targets required.
## DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS

## EXPERIMENT NO. AND TITLE: AFR3 - WILDLIFE-ECOSYSTEM STUDIES

<table>
<thead>
<tr>
<th>Targets</th>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Serengeti Plains</td>
<td>1°-3°30'S</td>
<td>33°-35°E</td>
</tr>
<tr>
<td>2</td>
<td>N. W. Oregon, near Bly</td>
<td>42°-43°N</td>
<td>121°-122°W</td>
</tr>
<tr>
<td>3</td>
<td>Alaska</td>
<td>65°-66°50'N</td>
<td>145°-150°W</td>
</tr>
</tbody>
</table>

### Observational Frequency (# Looks/# Days)
- **Desirable:** 2/1
- **Acceptable:** 1/2

### Altitude (n. mi.)
- **Desirable:** 100-150
- **Acceptable:** 150-300

### Illumination Constraints
- **Solar Elev. Angle (deg.):** ≥30; ≥20
- **Acceptable Time of Year:** Spring

### Target Location
- **F.O.V. (deg.):** 9.5
- **Off-Nadir Pointing (deg.):** +26.5

### Optimization
- **Mapping:**
- **Target Pass:**

### Comments
Any 2 targets required.
DISCIPLINE: AGRICULTURE, FORESTRY, RANGELANDS
EXPERIMENT NO. AND TITLE: AFR4 - WATER DAMAGE ASSESSMENT

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. N. Carolina</td>
<td>36°-36°30'N</td>
<td>81°-82°00'W</td>
</tr>
<tr>
<td>2. Tennessee</td>
<td>35°-36°N</td>
<td>83°-85°W</td>
</tr>
<tr>
<td>3. Georgia</td>
<td>34°40'-35°N</td>
<td>83°10'-84°40'W</td>
</tr>
</tbody>
</table>

Observational Frequency(# Looks/# Days) -
- Desirable: 2/5
- Acceptable: 1/5

Altitude (n. mi.) -
- Desirable: 100-150
- Acceptable: 150-300

Illumination Constraints -
- Solar Elev. Angle (deg.): ≥30
- Time of Year: March-April

Target Location -
- F.O.V. (deg.): 7
- Off-Nadir Pointing (deg.): +42

Optimization -
- Mapping:
- Target Pass: X

Comments -
- Any 1 target required
DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: O1 - REGIONAL WATER POLLUTION

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33.5°-34.5°N</td>
<td>118°-121°W</td>
</tr>
<tr>
<td>2</td>
<td>37°-39°N</td>
<td>121°-123°W</td>
</tr>
<tr>
<td>3</td>
<td>45.2°N</td>
<td>124°W</td>
</tr>
<tr>
<td>4</td>
<td>42°-48°N</td>
<td>75°-92°W</td>
</tr>
<tr>
<td>5</td>
<td>29°-30.5°N</td>
<td>89°-90°W</td>
</tr>
<tr>
<td>6</td>
<td>40.5°-41.5°N</td>
<td>72°-74°W</td>
</tr>
<tr>
<td>7</td>
<td>37°-40°N</td>
<td>75°-77°W</td>
</tr>
<tr>
<td>8</td>
<td>29°-30°N</td>
<td>94°-95.5°W</td>
</tr>
<tr>
<td>9</td>
<td>41.5°N</td>
<td>70.6°</td>
</tr>
<tr>
<td>10</td>
<td>30.4°N</td>
<td>88.5°</td>
</tr>
</tbody>
</table>

Observational Frequency [#Looks/#Days] -
Desirable: 2-3/1
Acceptable: 1/2

Altitude (n.m.) -
Desirable: 100-150
Acceptable: 150-250

Illumination Constraints -
Solar Elev. Angle (deg.): ≥30
Time of Year: April-May Desirable; Any Month Acceptable

Target Location -
F.O.V. (deg.): 51.3
Off-Nadir Pointing (deg.): ±25.7

Optimization -
Mapping:
Target Pass: X

Comments -
**DISCIPLINE:** OCEANOGRAPHY

**EXPERIMENT NO. AND TITLE:** 02 - SEA ICE MAPPING

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Pole</td>
<td>80°-85.5°S</td>
<td>-</td>
</tr>
<tr>
<td>North Pole</td>
<td>80°-85°N</td>
<td>-</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/#Days)**
- **Desirable:** 1/5
- **Acceptable:** 1/5

**Altitude (n.mi.)**
- **Desirable:** 100-150
- **Acceptable:** 150-250

**Illumination Constraints**
- **Solar Elev. Angle (deg.):** No Constraint
- **Time of Year:** No Constraint

**Target Location**
- **F.O.V. (deg.):** 12
- **Off-Nadir Pointing (deg.):** 450 to 462

**Optimization**
- **Mapping:**
- **Target Pass:** X

**Comments**
DISCIPLINE: OCEANOGRAPHY

EXPERIMENT NO. AND TITLE: 03 - PLANKTON PROFILING

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5°S-5°N</td>
<td>80°W-160°W</td>
</tr>
<tr>
<td>2</td>
<td>12°S-15°S</td>
<td>75°W-82°W</td>
</tr>
<tr>
<td>3</td>
<td>2°S-2°N</td>
<td>40°W-45°W</td>
</tr>
<tr>
<td>4</td>
<td>10°N-15°N</td>
<td>65°W-75°W</td>
</tr>
<tr>
<td>5</td>
<td>10°S-25°S</td>
<td>160°E-170°E</td>
</tr>
<tr>
<td>6</td>
<td>12°S-15°S</td>
<td>127°E-135°E</td>
</tr>
<tr>
<td>7</td>
<td>0°N-5°N</td>
<td>0°W-15°W</td>
</tr>
<tr>
<td>8</td>
<td>10°N-20°N</td>
<td>12°W-17°W</td>
</tr>
</tbody>
</table>

Observational Frequency(# Looks/#Days) —
Desirable: >3/1
Acceptable: 1/2

Altitude (n. mi.) —
Desirable: 100-150
Acceptable: 150-250

Illumination Constraints —
Solar Elev. Angle (deg.): 30°-90°
Time of Year: Local Spring or Summer or Major Targets

Target Location —
F. O. V. (deg.): 0°
Off-Nadir Pointing (deg.): 0°

Optimization —
Mapping:
Target Pass: X

Comments —
**DISCIPLINE:** OCEANOGRAPHY  
**EXPERIMENT NO. AND TITLE:** 04 - UPWELLING AREA MAPPING

<table>
<thead>
<tr>
<th>Targets</th>
<th>Number</th>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Observational Frequency (#Looks/#Days)</th>
<th>Altitude (n, mi.)</th>
<th>Illumination Constraints</th>
<th>Target Location</th>
<th>Optimization</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>5°S-5°N</td>
<td>80°W-160°W</td>
<td></td>
<td>Desirable: &gt;3/1</td>
<td></td>
<td></td>
<td>F.O.V. (deg.): 51.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12°S-15°S</td>
<td>75°W-82°</td>
<td></td>
<td>Acceptable: 1/1</td>
<td></td>
<td></td>
<td>Off-Nadir Pointing (deg.): ±25.7°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2°S-2°N</td>
<td>40°W-45°W</td>
<td></td>
<td>Desirable: 100-150</td>
<td></td>
<td></td>
<td>Time of Year: January-March</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>10°N-15°N</td>
<td>65°W-75°W</td>
<td></td>
<td>Acceptable: 150-250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>10°S-25°S</td>
<td>160°E-170°E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12°S-15°S</td>
<td>127°E-135°E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0°N-5°N</td>
<td>0°W-15°W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10°N-20°N</td>
<td>12°W-17°W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Observational Frequency (# Looks/# Days)**
- Desirable: 2-3/1
- Acceptable: 1/1

**Altitude (n. mi.)**
- Desirable: 100-150
- Acceptable: 150-250

**Illumination Constraints**
- Solar Elev. Angle (deg.): 30-90
- Time of Year: No Requirement

**Target Location**
- F.O.V. (deg.): 12
- Off-Nadir Pointing (deg.): +24° to 36°

**Optimization**
- Mapping:
  - Target Pass: X

**Comments**

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
</table>

No Need to Specify Targets Until the Orbit is Selected.
**DISCIPLINE:** OCEANOGRAHY  

**EXPERIMENT NO. AND TITLE:** 06 - SUN GLITTER/MOON GLITTER MEASUREMENTS  

<table>
<thead>
<tr>
<th>TARGETS</th>
<th>Observational Frequency (#Looks/#Days)</th>
<th>Altitude (n. mi.)</th>
<th>Illumination Constraints</th>
<th>Target Location</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number and Name</td>
<td>Desirable: 2-3/1</td>
<td>Desirable: 100-150</td>
<td>-</td>
<td>F. O. V. (deg.): 28</td>
<td>The desirable inclination is equal to the sun's declination.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time of Year: All Seasons</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No Need to Specify Targets Until the Orbit is Selected.
**DISCIPLINE: ENVIRONMENTAL IMPACT**

**EXPERIMENT NO. AND TITLE: E1 - MONITORING EFFECTS OF CHANGING LAND USE PATTERNS ON WILDLIFE**

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Serengeti Plains</td>
<td>1°-3°30' S</td>
<td>33°-35°E</td>
</tr>
<tr>
<td>2. Cape York</td>
<td>15°-19°S</td>
<td>141°-145°E</td>
</tr>
<tr>
<td>3. Pampas</td>
<td>36°-38°S</td>
<td>64°-68°W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Observational Frequency (#Looks/#Days)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Desirable: 1/5</td>
</tr>
<tr>
<td>Acceptable: 1/5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Altitude (n. mi.)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Desirable: 100-150</td>
</tr>
<tr>
<td>Acceptable:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Illumination Constraints</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Elev. Angle (deg.): &gt;30°</td>
</tr>
<tr>
<td>Time of Year: March-June; October-December</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Target Location</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>F.O.V. (deg.): 9.5°</td>
</tr>
<tr>
<td>Off-Nadir Pointing (deg.): ±26.5°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Optimization</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping:</td>
</tr>
<tr>
<td>Target Pass: X</td>
</tr>
</tbody>
</table>

**Comments**
**DISCIPLINE:** ENVIRONMENTAL IMPACT  
**EXPERIMENT NO. AND TITLE:** E2 - LAKE EUTROPHICATION

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Manitoba</td>
<td>50°30'N</td>
<td>98°30'W</td>
</tr>
<tr>
<td>Moosehead Lake</td>
<td>46°30'N</td>
<td>69°30'W</td>
</tr>
<tr>
<td>Lake Sebago</td>
<td>43°48'N</td>
<td>70°30'W</td>
</tr>
<tr>
<td>Grand Lake</td>
<td>49°N</td>
<td>57°30'W</td>
</tr>
<tr>
<td>Lake Champlain</td>
<td>44°30'N</td>
<td>73°12'W</td>
</tr>
<tr>
<td>Lake Winnipesaukee</td>
<td>43°30'N</td>
<td>71°24'W</td>
</tr>
<tr>
<td>Lake Ontario</td>
<td>43°30'N</td>
<td>77°W</td>
</tr>
<tr>
<td>Lake Simco</td>
<td>44°30'N</td>
<td>79°12'W</td>
</tr>
<tr>
<td>Mono Lake</td>
<td>38°N</td>
<td>119°W</td>
</tr>
<tr>
<td>Lake Winnebago</td>
<td>44°N</td>
<td>88°30'W</td>
</tr>
<tr>
<td>Lake Chippewa</td>
<td>45°54'N</td>
<td>91°12'W</td>
</tr>
<tr>
<td>Lake Moultrie</td>
<td>32°12'N</td>
<td>80°W</td>
</tr>
<tr>
<td>Lake Okeechobee</td>
<td>27°N</td>
<td>80°48'W</td>
</tr>
<tr>
<td>Douglas Lake</td>
<td>36°N</td>
<td>83°24'W</td>
</tr>
<tr>
<td>Lake Enid</td>
<td>34°06'N</td>
<td>89°54'W</td>
</tr>
<tr>
<td>White Lake</td>
<td>29°48'N</td>
<td>92°30'W</td>
</tr>
<tr>
<td>Lake of the Cherokees</td>
<td>36°30'N</td>
<td>94°48'W</td>
</tr>
<tr>
<td>Upper Red Lake</td>
<td>48°06'N</td>
<td>94°48'W</td>
</tr>
<tr>
<td>Leach Lake</td>
<td>47°06'N</td>
<td>94°30'W</td>
</tr>
<tr>
<td>Bear Lake</td>
<td>42°N</td>
<td>111°12'W</td>
</tr>
<tr>
<td>Utah Lake</td>
<td>40°12'N</td>
<td>111°48'W</td>
</tr>
<tr>
<td>Upper Klamath Lake</td>
<td>42°30'N</td>
<td>121°54'W</td>
</tr>
<tr>
<td>Yellowstone Lake</td>
<td>44°30'N</td>
<td>110°30'W</td>
</tr>
<tr>
<td>Flathead Lake</td>
<td>47°48'N</td>
<td>114°06'W</td>
</tr>
<tr>
<td>Lake Washington</td>
<td>47°30'N</td>
<td>122°30'W</td>
</tr>
<tr>
<td>Pyramid Lake</td>
<td>40°N</td>
<td>119°30'W</td>
</tr>
<tr>
<td>Lake Tahoe</td>
<td>39°N</td>
<td>120°W</td>
</tr>
</tbody>
</table>

**Observational Frequency [#Looks/#Days]**  
Desirable: 2/5  
Acceptable: 1/5

**Altitude (n. mi.)**  
Desirable: 100-150  
Acceptable: 150-300

**Illumination Constraints**  
Solar Elev. Angle (deg.): 45 Desirable; 30-60 Acceptable  
Time of Year: Spring Desirable; Spring or Autumn Acceptable

**Target Location**  
F.O.V. (deg.): 51.3  
Off-Nadir Pointing (deg.): ±25.7

**Optimisation**  
Mapping:  
Target Pass: X

**Comments**  
75 percent of targets required.
DISCIPLINE: ENVIRONMENTAL IMPACT

EXPERIMENT NO. AND TITLE: E3 - WATER USE PATTERN-IRRIGATION

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Euphrates River Area, Iraq</td>
<td>34°30' - 35°30'N</td>
<td>39° - 41°E</td>
</tr>
<tr>
<td></td>
<td>32°30' - 33°30'N</td>
<td>42° - 44°E</td>
</tr>
<tr>
<td></td>
<td>30°30' - 31°30'N</td>
<td>46° - 48°E</td>
</tr>
</tbody>
</table>

Observational Frequency (#Looks/#Days) —
Desirable: 1/1
Acceptable: 2/5

Altitude (n. mi.) —
Desirable: 100-150
Acceptable: 150-300

Illumination Constraints —
Solar Elev. Angle (deg.): 40 Desirable
40-60 Accept.
Time of Year: All Seasons; at or near Equinoxes or Solstices Desired.

Target Location —
F. O. V. (deg.): 9.5
Off-Nadir Pointing (deg.): ±26.5

Optimization —
Mapping:
Target Pass: X

Comments —
All targets required.
### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Majave Desert</td>
<td>34°30'N</td>
<td>117°W</td>
</tr>
<tr>
<td>2. Santa Lucia</td>
<td>14°N</td>
<td>61°W</td>
</tr>
<tr>
<td>3. Jamaica</td>
<td>18°N</td>
<td>77°W</td>
</tr>
<tr>
<td>4. Samoa</td>
<td>14°S</td>
<td>171°30'W</td>
</tr>
<tr>
<td>5. Papeete</td>
<td>17°42'S</td>
<td>149°12'W</td>
</tr>
<tr>
<td>6. Fiji</td>
<td>18°S</td>
<td>178°E</td>
</tr>
</tbody>
</table>

- **Observational Frequency (#Looks/#Days)**
  - Desirable: ≥2/5
  - Acceptable: 1/5
- **Altitude (n. mi.)**
  - Desirable: 150-150
  - Acceptable: 150-300
- **Illumination Constraints**
  - Time of Year: All Seasons
  - Target Location: Spring most desirable.
- **Optimization**
  - F.O.V. (deg.): 9.5°
  - Of: Nadir Pointing (deg.): ±26.5°

**DISCIPLINE**: HYDROLOGY

**EXPERIMENT NO. AND TITLE**: HI - GROUND WATER DISCHARGE AND MAPPING
**DISCIPLINE:** HYDROLOGY  
**EXPERIMENT NO. AND TITLE:** H2 - MAPPING GROUND STATE--FROZEN OR NOT

### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Plains</td>
<td>A 1° x 1° area within 45° - 50°N</td>
<td>A 1° x 1° area within 110° - 110°W</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>A 1° x 1° area within 40° - 45°N</td>
<td>A 1° x 1° area within 90° - 100°W</td>
</tr>
</tbody>
</table>

- **Observational Frequency (# Looks/#Days)**
  - Desirable: 1/1
  - Acceptable: 3/5
- **Altitude (n, mi.)**
  - Desirable: 100-150
  - Acceptable: 150-300
- **Illumination Constraints**
  - Solar Elev. Angle (deg.): 45 Des.
  - Time of Year: Spring 30-60 Acc.
- **Target Location**
  - F.O.V. (deg.): 12
  - Off-Nadir Pointing (deg.): ±50 to ±62
- **Optimization**
  - Mapping:
  - Target Pass: X
- **Comments**
  - Only one target desired.
DISCIPLINE: HYDROLOGY

EXPERIMENT NO. AND TITLE: H3 - SOIL MOISTURE MAPPING TECHNIQUE DEVELOPMENT

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mississippi</td>
<td>32° - 33°N</td>
<td>92° - 93°W</td>
</tr>
</tbody>
</table>

Observational Frequency (#Looks/#Days) -

- Desirable: 3/5
- Acceptable: 1/5

Altitude (m, mi.) -

- Desirable: 100-150
- Acceptable: 150-300

Illumination Constraints -

- Solar Elev. Angle (deg.): 45 Des. 30-60 Acc.
- Time of Year: Spring

Target Location -

- F.O.V. (deg.): 12
- Off-Nadir Pointing (deg.): 24 - 36

Optimization -

- Mapping:
  - Target Pass: T

Comments -
**DISCIPLINE:** HYDROLOGY  
**EXPERIMENT NO. AND TITLE:** H4 - SNOW AND ICE MONITORING

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar Regions (N and S)</td>
<td>65° - 90°N; 65° - 90°S</td>
<td>All Longitudes</td>
</tr>
</tbody>
</table>

**Observational Frequency (#Looks/#Days) —**
- Desirable: 2/5
- Acceptable: 1/5

**Altitude (n. mi.) —**
- Desirable: 100-150
- Acceptable: 150-300

**Illumination Constraints —**
- Solar Elev. Angle (deg.): >15 Des. 5-40 Acc.
- Time of Year:
  - Most Desirable: June-July (Northern Hemisphere)  
  - Dec-Jan (Southern Hemisphere)  
  - All Months Acceptable

**Target Location —**
- F.O.V. (deg.): 14.5
- Off-Nadir Pointing (deg.): 22.7 to 37.3

**Optimization —**
- Mapping:

**Target Pass: X**

**Comments —**
### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mississippi Basin</td>
<td>$35^\circ N \pm 1.5^\circ$</td>
<td>$90^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>2. High Plains</td>
<td>$35^\circ N \pm 1.5^\circ$</td>
<td>$100^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>3. MRN, Great Plains</td>
<td>$45^\circ N \pm 1.5^\circ$</td>
<td>$100^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>4. East Coast U.S.</td>
<td>$35^\circ N \pm 1.5^\circ$</td>
<td>$77^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>5. Florida</td>
<td>$27^\circ N \pm 1.5^\circ$</td>
<td>$82^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>6. Paraguay</td>
<td>$25^\circ S \pm 1.5^\circ$</td>
<td>$60^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>7. NE Brazil</td>
<td>$12^\circ S \pm 1.5^\circ$</td>
<td>$40^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>8. Australia, N</td>
<td>$20^\circ S \pm 1.5^\circ$</td>
<td>$141^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>9. Australia, W</td>
<td>$30^\circ S \pm 1.5^\circ$</td>
<td>$120^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>10. Chad, Africa</td>
<td>$13^\circ N \pm 1.5^\circ$</td>
<td>$15^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>11. Timbuktu</td>
<td>$16^\circ N \pm 1.5^\circ$</td>
<td>$3^\circ W \pm 1.5^\circ$</td>
</tr>
<tr>
<td>12. Okovango</td>
<td>$19^\circ S \pm 1.5^\circ$</td>
<td>$20^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>13. Bourdeaux, France</td>
<td>$43^\circ N \pm 1.5^\circ$</td>
<td>$0^\circ \pm 1.5^\circ$</td>
</tr>
<tr>
<td>14. Hamburg</td>
<td>$53^\circ N \pm 1.5^\circ$</td>
<td>$10^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>15. Kiev</td>
<td>$50.5^\circ N \pm 1.5^\circ$</td>
<td>$31^\circ E \pm 1.5^\circ$</td>
</tr>
<tr>
<td>16. Iran</td>
<td>$30^\circ N \pm 1.5^\circ$</td>
<td>$53^\circ E \pm 1.5^\circ$</td>
</tr>
</tbody>
</table>

### Observational Frequency (#Looks/#Days)

- **Desirable:** 1/5
- **Acceptable:** 1/5

### Altitude (m. mi.)

- **Desirable:** 100-150
- **Acceptable:** 150-300

### Illumination Constraints

- **Solar Elev. Angle (deg.):** 5 - 75
- **Time of Year:** Spring, Des., Any Season, Acceptable

### Target Location

- **F.O.V. (deg.):** 14.5
- **Off-Nadir Pointing (deg.):** +22.7 to +37.3

### Optimization

- **Mapping:**
- **Target Pass:** X

### Comments

- 75 percent of targets required.
### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mt. Rainier, Washington</td>
<td>46°30' - 47°N</td>
<td>121°30' - 122°W</td>
</tr>
<tr>
<td>2. Lawrence, Kansas</td>
<td>38°30' - 39°N</td>
<td>95° - 96°30'W</td>
</tr>
<tr>
<td>3. Harper's Ferry, W. Va.</td>
<td>39°30' - 30°N</td>
<td>77°30' - 78°W</td>
</tr>
<tr>
<td>4. Boulder, Colo.</td>
<td>40° - 40°30'N</td>
<td>105° - 105°30'N</td>
</tr>
<tr>
<td>5. N. Borneo</td>
<td>6°-7°N</td>
<td>117°-118°E</td>
</tr>
<tr>
<td>6. Zaire</td>
<td>0°-1°S</td>
<td>20°-21°E</td>
</tr>
<tr>
<td>7. Santarem, Brazil</td>
<td>2°-3°S</td>
<td>54°-55°W</td>
</tr>
<tr>
<td>8. Near Cayenne, Fr. Guiana</td>
<td>4°-5°N</td>
<td>52°-53°W</td>
</tr>
</tbody>
</table>

### Observational Frequency (#Looks/#Days)
- Desirable: 4/5 (2 at each solar elev. angle)
- Acceptable: 2/5 (2 at each solar elev. angle)

### Altitude (n. mi.)
- Desirable: 100-150
- Acceptable: 150-300

### Illumination Constraints

<table>
<thead>
<tr>
<th>Solar Elevation Angle (deg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Rainier, Wash.</td>
</tr>
<tr>
<td>Lawrence, Kas.</td>
</tr>
<tr>
<td>Harper's Ferry, Colo.</td>
</tr>
<tr>
<td>Boulder, Colo.</td>
</tr>
<tr>
<td>N. Borneo</td>
</tr>
<tr>
<td>Zaire</td>
</tr>
<tr>
<td>Santarem, Brazil</td>
</tr>
<tr>
<td>Near Cayenne, Fr. Guiana</td>
</tr>
</tbody>
</table>

### Time of Year: Summer; prefer June

### Target Location
- F.O.V. (deg): 1.75
- Off-Nadir Pointing: +41

### Optimization
- Mapping:
- Target Pass: X

### Comments
- Low solar elevation angles for lower resolution visible sensors; higher solar elevation angles for high resolution sensors.
- Prefer early A.M. for equatorial targets; late P.M. for mid-latitude targets.
- Any two targets required.
DISCIPLINE: OTHERS

EXPERIMENT NO. AND TITLE: OTF - INTERNATIONAL DEVELOPMENT PROJECT
PRE-FEASIBILITY ANALYSIS

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Petrolina, Brazil</td>
<td>8°-9°30'S</td>
<td>40°-42°W</td>
</tr>
<tr>
<td>2. Surinam</td>
<td>3°50'N-4°20'N</td>
<td>34°-55°W</td>
</tr>
<tr>
<td>3. Awash Valley, Ethiopia</td>
<td>10°11°N</td>
<td>54°-55°W</td>
</tr>
<tr>
<td>4. Morocco</td>
<td>33°-34°N</td>
<td>3°-4°W</td>
</tr>
<tr>
<td>5. Zaire</td>
<td>10°-11°S</td>
<td>25°-26°E</td>
</tr>
<tr>
<td>6. Headwaters, Digoel River,</td>
<td>5°-6°S</td>
<td>140°-141°E</td>
</tr>
<tr>
<td>W. Irian</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observational Frequency (#Looks/#Days) -
Desirable: 2/5
Acceptable: 1/5

Altitude (n. mi.) -
Desirable: 100-150
Acceptable: 150-300

Illumination Constraints -
Solar Elev. Angle (deg.): ≥30
Time of Year: All Seasons

Target Location -
F. O. V. (deg.): 8, 6
Off-Nadir Pointing (deg.): ±25.7 to 34.3

Optimization -
Mapping:
Target Pass: X

Comments -
Two targets required.
### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, DC</td>
<td>38°50'N</td>
<td>77°W</td>
</tr>
<tr>
<td>San Francisco</td>
<td>37°45'N</td>
<td>122°26'W</td>
</tr>
<tr>
<td>Boston</td>
<td>42°15'N</td>
<td>71°07'W</td>
</tr>
<tr>
<td>Seattle</td>
<td>47°36'N</td>
<td>122°20'W</td>
</tr>
<tr>
<td>Dallas</td>
<td>32°45'N</td>
<td>96°48'W</td>
</tr>
<tr>
<td>Kansas City, Mo.</td>
<td>39°05'N</td>
<td>94°35'W</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>34°00'N</td>
<td>118°15'W</td>
</tr>
<tr>
<td>Chicago</td>
<td>41°49'N</td>
<td>87°37'W</td>
</tr>
<tr>
<td>St. Louis</td>
<td>38°39'N</td>
<td>90°15'W</td>
</tr>
<tr>
<td>Houston</td>
<td>29°46'N</td>
<td>95°21'W</td>
</tr>
<tr>
<td>New York</td>
<td>40°40'N</td>
<td>73°58'W</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>40°26'N</td>
<td>80°01'W</td>
</tr>
<tr>
<td>Denver</td>
<td>39°44'N</td>
<td>104°59'W</td>
</tr>
<tr>
<td>Sydney</td>
<td>33°55'S</td>
<td>151°17'E</td>
</tr>
<tr>
<td>Calcutta</td>
<td>22°32'N</td>
<td>88°22'E</td>
</tr>
<tr>
<td>Sao Paulo</td>
<td>23°34'S</td>
<td>46°38'W</td>
</tr>
<tr>
<td>Buenos Aires</td>
<td>34°20'S</td>
<td>58°30'W</td>
</tr>
<tr>
<td>Santiago</td>
<td>33°26'S</td>
<td>70°40'W</td>
</tr>
<tr>
<td>Mexico City</td>
<td>19°25'S</td>
<td>99°09'W</td>
</tr>
<tr>
<td>Montreal</td>
<td>45°30'N</td>
<td>73°35'W</td>
</tr>
<tr>
<td>Djakarta</td>
<td>6°17'S</td>
<td>106°45'E</td>
</tr>
<tr>
<td>Cape Town</td>
<td>33°48'S</td>
<td>18°28'E</td>
</tr>
<tr>
<td>Madrid</td>
<td>40°26'N</td>
<td>3°42'W</td>
</tr>
<tr>
<td>Teheran</td>
<td>35°45'N</td>
<td>51°30'E</td>
</tr>
<tr>
<td>Ankara</td>
<td>39°55'N</td>
<td>32°50'E</td>
</tr>
<tr>
<td>Algiers</td>
<td>36°51'N</td>
<td>2°56'E</td>
</tr>
<tr>
<td>London</td>
<td>51°30'N</td>
<td>0°07'W</td>
</tr>
</tbody>
</table>

#### Observational Frequency (#Looks/#Days)
- **Desirable:** 2/5
- **Acceptable:** 1/5

#### Altitude (n. mi.)
- **Desirable:** 100-150
- **Acceptable:** 150-300

#### Illumination Constraints
- **Solar Elev. Angle (deg.):** ≥30
- **Time of Year:** ♦

#### Target Location
- **F. O. V. (deg.):** 9.5
- **Off-Nadir Pointing (deg.):** ±26.5

#### Optimization
- **Mapping:**
- **Target Pass:** X

#### Comments
- Any 10 targets required.

*Except for Washington, D.C. at 10°

**Order of Preference:
- Spring or Autumn, Summer, Winter
### EXPERIMENT NO. AND TITLE: G1 - RAPID GEOLOGIC RECONNAISSANCE MAPPING

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algeria</td>
<td>20°N ±1.5°</td>
<td>10°W ±1.5°</td>
</tr>
<tr>
<td>2. Libya</td>
<td>29°N ±1.5°</td>
<td>15°E ±1.5°</td>
</tr>
<tr>
<td>3. UAR</td>
<td>29°N ±1.5°</td>
<td>29°E ±1.5°</td>
</tr>
<tr>
<td>4. Kalahari Desert</td>
<td>23°S ±1.5°</td>
<td>22°E ±1.5°</td>
</tr>
<tr>
<td>5. Great Sands Desert</td>
<td>20°S ±1.5°</td>
<td>125°E ±1.5°</td>
</tr>
<tr>
<td>6. Great Victoria Desert</td>
<td>29°S ±1.5°</td>
<td>125°E ±1.5°</td>
</tr>
<tr>
<td>7. Mojave Desert</td>
<td>35°N ±1.5°</td>
<td>117°W ±1.5°</td>
</tr>
<tr>
<td>8. W. Texas</td>
<td>33.5°N ±1.5°</td>
<td>102°W ±1.5°</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/# Days)**
- **Desirable:** 2/5
- **Acceptable:** 1/5

**Altitude (n. mi.)**
- **Desirable:** 100-150
- **Acceptable:** 150-300

**Illumination Constraints**
- **Solar Elev. Angle (deg.):** 25-40
- **Time of Year:** Any Season

**Target Location**
- **F.O.V. (deg.):** 14.5
- **Off-Nadir Pointing (deg.):** +22.7 to 37.3

**Optimization**
- Mapping:
- Target Pass:

**Comments**
- Required: 1 target from targets 7 and 8; then, at least 2 targets from targets 1 to 6.
## DISCIPLINE: GEOLOGY

## EXPERIMENT NO. AND TITLE: GZ - COASTAL GEOLOGY AND GEOMORPHIC PROCESSES

### TARGETS

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. S. E. U.S. Coast</td>
<td>32°N ±1°</td>
<td>81°W ±1°</td>
</tr>
<tr>
<td></td>
<td>34°N ±1°</td>
<td>78°W ±1°</td>
</tr>
<tr>
<td></td>
<td>36°N ±1°</td>
<td>76°W ±1°</td>
</tr>
<tr>
<td>2. N. E. U.S. Coast</td>
<td>38°N ±1°</td>
<td>76°W ±1°</td>
</tr>
<tr>
<td></td>
<td>40°N ±1°</td>
<td>74°W ±1°</td>
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<tr>
<td></td>
<td>42°N ±1°</td>
<td>71°W ±1°</td>
</tr>
<tr>
<td></td>
<td>44°N ±1°</td>
<td>69°W ±1°</td>
</tr>
<tr>
<td>3. W. Coast U.S.</td>
<td>40°N ±1°</td>
<td>124°W ±1°</td>
</tr>
<tr>
<td></td>
<td>37°N ±1°</td>
<td>122°W ±1°</td>
</tr>
<tr>
<td></td>
<td>34°N ±1°</td>
<td>119°W ±1°</td>
</tr>
<tr>
<td></td>
<td>32°N ±1°</td>
<td>117°W ±1°</td>
</tr>
<tr>
<td>4. E. Coast, S. America</td>
<td>40°S ±1°</td>
<td>64°W ±1°</td>
</tr>
<tr>
<td></td>
<td>36°S ±1°</td>
<td>58°W ±1°</td>
</tr>
<tr>
<td></td>
<td>32°S ±1°</td>
<td>52°W ±1°</td>
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<tr>
<td></td>
<td>26°S ±1°</td>
<td>48°W ±1°</td>
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<td>20°S ±1°</td>
<td>40°W ±1°</td>
</tr>
<tr>
<td></td>
<td>14°S ±1°</td>
<td>39°W ±1°</td>
</tr>
</tbody>
</table>

### Observational Frequency (# Looks/# Days)
- Desirable: 2/5
- Acceptable: 1/5

### Altitude (n. mi.)
- Desirable: 100-150
- Acceptable: 150-300

### Illumination Constraints
- Solar Elev. Angle (deg.): ≥60 Des.  ≥ 40 Acc.
- Time of Year: All Seasons

### Target Location
- F.O.V. (deg.): 14.5
- Off-Nadir Pointing (deg.): +22.7 to 37.3

### Optimization
- Mapping:
- Target Pass: X

### Comments
- 4 targets required, with ≥50% of sub-taets required within each of 4 target area.

*Late Spring Most Desired*
<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. W. Coast, Africa</td>
<td>34°S ±1°</td>
<td>19°E ±1°</td>
</tr>
<tr>
<td></td>
<td>26°S ±1°</td>
<td>16°E ±1°</td>
</tr>
<tr>
<td></td>
<td>24°S ±1°</td>
<td>15°E ±1°</td>
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<tr>
<td></td>
<td>20°S ±1°</td>
<td>13°E ±1°</td>
</tr>
<tr>
<td></td>
<td>16°S ±1°</td>
<td>12°E ±1°</td>
</tr>
<tr>
<td></td>
<td>12°S ±1°</td>
<td>14°E ±1°</td>
</tr>
<tr>
<td>6. Sumatra Coast</td>
<td>5°N ±1°</td>
<td>95°E ±1°</td>
</tr>
<tr>
<td></td>
<td>0° ±1°</td>
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</tr>
<tr>
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<td>0° ±1°</td>
<td>104°E ±1°</td>
</tr>
<tr>
<td></td>
<td>3°N ±1°</td>
<td>100°E ±1°</td>
</tr>
<tr>
<td>7. E. Coast, Africa</td>
<td>32°S ±1°</td>
<td>29°E ±1°</td>
</tr>
<tr>
<td></td>
<td>26°S ±1°</td>
<td>32°E ±1°</td>
</tr>
<tr>
<td></td>
<td>24°S ±1°</td>
<td>35°E ±1°</td>
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<td>20°S ±1°</td>
<td>35°E ±1°</td>
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<tr>
<td></td>
<td>18°S ±1°</td>
<td>37°E ±1°</td>
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<td>12°S ±1°</td>
<td>40°E ±1°</td>
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<td>4°S ±1°</td>
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<td></td>
<td>2°N ±1°</td>
<td>45°E ±1°</td>
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<td>6°N ±1°</td>
<td>49°E ±1°</td>
</tr>
<tr>
<td></td>
<td>10°N ±1°</td>
<td>47°E ±1°</td>
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(continued)
<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Sea</td>
<td>$22^\circ N \pm 1^\circ$</td>
<td>$37^\circ E \pm 1^\circ$</td>
</tr>
<tr>
<td></td>
<td>$18^\circ N \pm 1^\circ$</td>
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<td>$14^\circ N \pm 1^\circ$</td>
<td>$42^\circ E \pm 1^\circ$</td>
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<tr>
<td></td>
<td>$11^\circ N \pm 1^\circ$</td>
<td>$44^\circ E \pm 1^\circ$</td>
</tr>
<tr>
<td>Number and Name</td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1. Ethiopia</td>
<td>8°-12°N</td>
<td>35°-41°E</td>
</tr>
<tr>
<td></td>
<td>25°30'-28°30'N</td>
<td>86°30'-93°30'E</td>
</tr>
<tr>
<td></td>
<td>29°30'-32°30'N</td>
<td>76°30'-83°30'E</td>
</tr>
<tr>
<td></td>
<td>26°30'-29°30'N</td>
<td>81°30'-88°30'E</td>
</tr>
<tr>
<td></td>
<td>34°30'-37°30'N</td>
<td>71°30'-78°30'E</td>
</tr>
<tr>
<td></td>
<td>34°30'-37°30'N</td>
<td>66°30'-73°30'E</td>
</tr>
<tr>
<td></td>
<td>26°30'-29°30'N</td>
<td>91°30'-98°30'E</td>
</tr>
<tr>
<td>2. New Guinea</td>
<td>2°30'-5°30'S</td>
<td>135°30'-138°30'E</td>
</tr>
<tr>
<td></td>
<td>4°30'-7°30'S</td>
<td>143°30'-146°30'E</td>
</tr>
<tr>
<td>3. Turkey</td>
<td>37°-40°N</td>
<td>32°-38°E</td>
</tr>
<tr>
<td></td>
<td>36°-39°N</td>
<td>36°-42°E</td>
</tr>
<tr>
<td></td>
<td>37°-40°N</td>
<td>38°-44°E</td>
</tr>
<tr>
<td>4. Pyrenees Mountains</td>
<td>42°-43°N</td>
<td>1°W-3°E</td>
</tr>
<tr>
<td>5. Alps</td>
<td>42°30'-45°30'N</td>
<td>5°30'-8°30'E</td>
</tr>
<tr>
<td></td>
<td>44°30'-47°30'N</td>
<td>6°30'-9°30'E</td>
</tr>
<tr>
<td></td>
<td>45°30'-48°30'N</td>
<td>8°30'-11°30'E</td>
</tr>
<tr>
<td></td>
<td>45°30'-48°30'N</td>
<td>11°30'-14°30'E</td>
</tr>
</tbody>
</table>

**Observational Frequency (Number of Looks/Number of Days)**
- Desirable: 2/5
- Acceptable: 1/5

**Altitude (n. mi.)**
- Desirable: 100-150
- Acceptable: 150-300

**Illumination Constraints**
- Solar Elev. Angle (deg.): >60 Acc.
- Time of Year: All Seasons

**Target Location**
- F. O. V. (deg.): 14.5
- Off-Nadir Pointing (deg.): ±22.7 to 37.3

**Optimization**
- Mapping:
  - Target Pass: X

**Comments**
- For each of at least 4 targets, at least 50% of specified areas must be ≥75% mapped.

*Desired near Solstices and Equinoxes*
<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Andes</td>
<td>1°30'N-1°30'S</td>
<td>79°-81°W</td>
</tr>
<tr>
<td></td>
<td>3°30'-6°30'S</td>
<td>78°-80°W</td>
</tr>
<tr>
<td></td>
<td>8°30'-11°30'S</td>
<td>76°-78°W</td>
</tr>
<tr>
<td></td>
<td>13°30'-16°30'S</td>
<td>70°-72°W</td>
</tr>
<tr>
<td></td>
<td>18°30'-21°30'S</td>
<td>68°-70°W</td>
</tr>
<tr>
<td></td>
<td>28°30'-31°30'S</td>
<td>66°-70°W</td>
</tr>
<tr>
<td></td>
<td>38°30'-41°30'S</td>
<td>70°-72°W</td>
</tr>
<tr>
<td></td>
<td>48°30'-51°30'S</td>
<td>71°-73°W</td>
</tr>
<tr>
<td>7. Rocky Mountains</td>
<td>58°30'-61°30'N</td>
<td>129°-131°W</td>
</tr>
<tr>
<td></td>
<td>48°30'-51°30'N</td>
<td>114°-116°W</td>
</tr>
<tr>
<td></td>
<td>38°30'-41°30'N</td>
<td>106°-108°W</td>
</tr>
<tr>
<td></td>
<td>28°30'-31°30'N</td>
<td>104°-106°W</td>
</tr>
<tr>
<td></td>
<td>23°30'-26°30'N</td>
<td>99°-101°W</td>
</tr>
<tr>
<td>8. Sierra Mountains</td>
<td>48°30'-51°30'N</td>
<td>119°-120°30'W</td>
</tr>
<tr>
<td></td>
<td>38°30'-41°30'N</td>
<td>120°30'-121°30'W</td>
</tr>
</tbody>
</table>
### DISCIPLINE: METEOROLOGY

**EXPERIMENT NO. AND TITLE:** MI - NOCTILUCENT CLOUD PATROL

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noctilucent Clouds at ~80 Km Altitude</td>
<td>60° - 80°N</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Desirable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45° - 80°N</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

#### Observational Frequency (#Looks/#Days) -
- **Desirable:** Whenever detected.
- **Acceptable:** Whenever detected.

#### Altitude (n. mi.) -
- **Desirable:** ≤300
- **Acceptable:** ≤300

#### Illumination Constraints -
- **Solar Elev. Angle (deg.):** Observations made in twilight zone.
- **Time of Year:** Summer

#### Target Location -
- **F. O. V. (deg.):** N/A
- **Off-Nadir Pointing (deg.):** N/A

#### Optimization -
- **Mapping:**
- **Target Pass:** X

#### Comments -
*Targets of opportunity; detection required; astronaut scans twilight horizon.*
**DISCIPLINE:** METEOROLOGY  
**EXPERIMENT NO. AND TITLE:** M2 - STELLAR OCCULTATION

<table>
<thead>
<tr>
<th>TARGETS</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>stars</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>All Desirable; 30°N to 30°S</td>
<td>All Desirable; 30°N to 30°S</td>
</tr>
<tr>
<td></td>
<td>Acceptable</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/#Days)**

- Desirable: 4-5 stars/orbit; 20 orbits/5 days
- Acceptable: 4-5 stars/orbit; 10 orbits/10 days

**Altitude (n. mi.)**

- Desirable: >100
- Acceptable: 100-300

**Illumination Constraints**

- Solar Elev. Angle (deg.): Night-time measurements
- Time of Year: No Preference

**Target Location**

- F.O.V. (deg.): N/A
- Off-Nadir Pointing (deg.): N/A

**Optimization**

- Mapping:
  - Target Pass: X

**Comments**

Stellar acquisition plus tracking time/ star ~6 minutes.
**DISCIPLINE:** METEOROLOGY

**EXPERIMENT NO. AND TITLE:** M3 - GLOBAL THUNDERSTORM AND LIGHTNING

---

### TARGETS

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thunderstorms, line squalls, clouds with convective activity</td>
<td>50°N to 50°S, 30°N to 30°S</td>
<td>No Preference, Acceptable</td>
</tr>
<tr>
<td>Truth Sites</td>
<td>36°30'N, 28°40'N</td>
<td>117°W, 80°40'W</td>
</tr>
</tbody>
</table>

### Observational Frequency (# Looks/#Days)

- See Comments: Sufficient Observational opportunities exist.
- Truth Sites —
  - Desirable: 1/2.5
  - Acceptable: 1/5

### Altitude (n. mi.)

- Desirable: 100-200
- Acceptable: 400

### Illumination Constraints

- Solar Elev. Angle (deg.): No requirement
- Time of Year: All seasons

### Target Location

- F.O.V. (deg.): 28
- Off-Nadir Pointing (deg.): ±42

### Optimization

- Mapping:
- Target Pass: X

### Comments

Targets are mostly those of opportunity.

Both truth sites are required.
**DIscipline: Meteorology**

**Experiment No. and Title:** M4 - Air Pollution Monitoring

### Targets

<table>
<thead>
<tr>
<th>Number and Name</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Los Angeles</td>
<td>33.7°-34.4°N</td>
<td>117°-119°W</td>
</tr>
<tr>
<td>2. San Francisco</td>
<td>37.2°-38.1°N</td>
<td>121.9°-122.6°W</td>
</tr>
<tr>
<td>3. San Diego</td>
<td>32.5°-33.0°N</td>
<td>116.6°-117.3°W</td>
</tr>
<tr>
<td>4. Salt Lake City</td>
<td>40.5°-41.1°N</td>
<td>111.7°-112.2°W</td>
</tr>
<tr>
<td>5. Houston</td>
<td>29.3°-30.2°N</td>
<td>94.8°-95.7°W</td>
</tr>
<tr>
<td>6. St. Louis</td>
<td>38.4°-39.0°N</td>
<td>89.8°-90.5°W</td>
</tr>
<tr>
<td>7. Chicago</td>
<td>41.4°-42.2°N</td>
<td>97.1°-88.1°W</td>
</tr>
<tr>
<td>8. Atlanta</td>
<td>33.5°-34.0°N</td>
<td>84.2°-84.6°W</td>
</tr>
<tr>
<td>9. Birmingham</td>
<td>33.3°-33.8°N</td>
<td>86.5°-87.1°W</td>
</tr>
<tr>
<td>10. Boston</td>
<td>42.1°-42.6°N</td>
<td>70.7°-71.4°W</td>
</tr>
<tr>
<td>11. Pittsburgh</td>
<td>40.2°-40.8°N</td>
<td>79.6°-80.5°W</td>
</tr>
<tr>
<td>12. Miami</td>
<td>25.5°-26.1°N</td>
<td>80.0°-80.5°W</td>
</tr>
<tr>
<td>13. New York</td>
<td>40.4°-41.1°N</td>
<td>73.6°-74.4°W</td>
</tr>
<tr>
<td>14. Philadelphia</td>
<td>39.75°-40.25°N</td>
<td>74.8°-75.8°W</td>
</tr>
<tr>
<td>15. Washington/Baltimore</td>
<td>38.7°-39.4°N</td>
<td>76.4°-77.3°W</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/#Days) -**
- Desirable: 2-3/1
- Acceptable: 2/5

**Altitude (n. mi.) -**
- Desirable: 100-150
- Acceptable: 150-300

**Illumination Constraints -**
- Solar Elev. Angle (deg.): ≥30
- Time of Year: All Seasons

**Target Location -**
- F.O.V. (deg.): 5
- Off-Nadir Pointing (deg.): 421

**Optimization -**
- Mapping:

**Comments -**
- At least eight targets from target list are required.

*Priority: Autumn over Eastern U.S. and Summer over extreme Western U.S.*
**DISCIPLINE:** METEOROLOGY  

**EXPERIMENT NO. AND TITLE:** M5 - WEATHER MODIFICATION -- TROPICAL STORMS

<table>
<thead>
<tr>
<th>TARGETS</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricanes</td>
<td>For the Gulf of Mexico, Caribbean, N. Atlantic (15° - 35°N), any 5°x5° square</td>
<td>60° - 95°W</td>
</tr>
</tbody>
</table>

**Observational Frequency (# Looks/# Days)**  
- Desirable: 3/1 for 4 consecutive days.  
- Acceptable: 1/1 for 3 consecutive days.

**Altitude (n. mi.)**  
- Desirable: ≤200  
- Acceptable: 200-400

**Illumination Constraints**  
- Solar Elev. Angle (deg.): ≥25°  
- Time of Year: August-October

**Target Location**  
- F.O.V. (deg.): 28  
- Off-Nadir Pointing (deg.): 42

**Optimization**  
- Mapping: X

**Comments**  
- 5° x 5° Lat/Long target area will move 5° to 10°/day in latitude and/or longitude.
**Observational Frequency** (#Looks/#Days) —
- Desirable: 2/5
- Acceptable: 1/5

**Altitude (n. mi.)** —
- Desirable: \(<200\)
- Acceptable: 200-400

**Illumination Constraints** —
- Solar Elev. Angle (deg.): No Requirement
- Time of Year: All Seasons.

**Target Location** —
- F.O.V. (deg.): 12
- Off-Nadir Pointing (deg.): 450 to 162

**Optimization** —
- Mapping:
- Target Pass: X

**Comments** —

* Highest Priority Feb. and Sept.
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 14. IR MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.150 m³ (5 ft³)
   - WEIGHT: 47 Kg (103 lb)
   - POWER: 90 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>Over land masses</td>
</tr>
<tr>
<td>Power</td>
<td>90 W</td>
<td>90 W</td>
<td>90 W</td>
<td>0 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>7.45 MB/S (33% duty cycle)</td>
<td>7.45 MB/S (33% duty cycle)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1/4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
**SENSOR:** 15. HIGH RESOLUTION VISIBLE IMAGING SPECTROMETER

### 1) PHYSICAL REQUIREMENTS:
- **SIZE:** $0.012 \, \text{m}^3 (0.43 \, \text{ft}^3)$ Spectrometer
- **WEIGHT:** $13.6 \, \text{Kg (30 lb)}$ Spectrometer, $11.4 \, \text{Kg (25 lb)}$ Gimbals
- **POWER:** $25 \, \text{W Spectrometer}$, $25 \, \text{W (av), 100 W (pk) Gimbals}$

### 2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong> (Standard, or Min/Max)</td>
<td>10 min. (warm-up)</td>
<td>5 min.</td>
<td>18 sec. (3 frames) per target</td>
<td>Time between targets</td>
<td>Over land masses and during eclipse</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>50 W</td>
<td>125 W (2-axis pointing)</td>
<td>125 W (2-axis pointing)</td>
<td>50 W</td>
<td>0 W</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>-</td>
<td>6 KB/S</td>
<td>6 KB/S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Film</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Manpower</strong></td>
<td>$1/2$</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Special</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: HIGH RESOLUTION IR MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:
- SIZE: \(0.028 \text{ m}^3 (1.0 \text{ ft}^3)\) Scanner
- WEIGHT: 25 Kg (55 lb) Scanner
- POWER: 90 W (Scanner)
- WEIGHT: \(0.01 \text{ m}^3 (0.35 \text{ ft}^3)\) Gimbals
- WEIGHT: 11.4 Kg (25 lb) Gimbals
- POWER: 25 W (av) 100 W (pk) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>15 sec</td>
<td>Time between targets</td>
<td>Over land masses</td>
</tr>
<tr>
<td>Power</td>
<td>115 W</td>
<td>190 W (2-axis pointing)</td>
<td>190 W (2-axis pointing)</td>
<td>115 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>240 KB/S</td>
<td>240 KB/S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1/2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 17. GLITTER FRAMING CAMERA

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.008 m³ (0.29 ft³) Camera
   - WEIGHT: 7.3 Kg (16 lb) Camera
   - POWER: 10 W Camera
   - SIZE: 0.006 m³ (0.20 ft³) Gimbals
   - WEIGHT: 5.5 Kg (12 lb) Gimbals
   - POWER: 10 W (av), 30 W (pk) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>5 min.</td>
<td>10 sec./target</td>
<td>Time between targets</td>
<td>During eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>10 W</td>
<td>30 W</td>
<td>30 W</td>
<td>10 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>1.2 MB/S</td>
<td>1.2 MB/S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 18. STAR TRACKING TELESCOPE

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.15 m³ (3.8 ft³)
   - WEIGHT: 50 Kg (110 lbs)
   - POWER: 60 W warm-up
     104 W pk
     65 W av

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>15 min. (warm-up)</td>
<td>15 min.</td>
<td>2 min./acquisition 4 minutes/sighting</td>
<td>Between sightings</td>
<td>During daylight</td>
</tr>
<tr>
<td>Power</td>
<td>60 W</td>
<td>104 W</td>
<td>104 W</td>
<td>65 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>890 B/S</td>
<td>890 B/S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>10 frames 35 mm film</td>
<td>4 frames 35 mm film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
APPENDIX C

SENSOR INPUTS TO AESOP
APPENDIX C

SENSOR INPUTS TO AESOP

The AESOP program requires three inputs: sensor data bank, mission/experiment priorities and an ephemeris tape. The former input is contained in this Appendix. It consists of:

- Resource requirements/sensor events matrices
- Sequencing matrices
- Operational priorities

The first part of the Appendix lists the resource requirements/sensor events matrices for each of the 33 sensors associated with the Level 1 experiments. The sensors are then grouped according to similarities in their sequencing requirements and operational priorities.
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 1. TRACKING TELESCOPE

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.375 m³
   - WEIGHT: 317 Kg (700 lb.)
   - POWER: 94 W (av.), 125 W (pk.)

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/ Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>5 min. (warm-up)</td>
<td>10 min.</td>
<td>2 min/target</td>
<td>Time Between Targets</td>
<td>During Eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>94 W</td>
<td>125 W</td>
<td>125 W</td>
<td>94 W</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>3 Frames/60 sec.</td>
<td>35 mm Film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1-1/2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA P NK

SENSOR: 2. POINTABLE IDENTIFICATION CAMERA (70 MM)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.03 m³ Camera
   - WEIGHT: 23 Kg (50 lb) Camera
   - Gimbals
   - WEIGHT: 23 Kg (50 lb) Gimbals
   - POWER: 50 W (av.), 80 W (pk.) Camera
   - 30 W (av.), 100 W (pk.) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>5 min.</td>
<td>10 sec./target</td>
<td>Time Between Targets</td>
<td>During Eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>110 W</td>
<td>150 W (Pointing)</td>
<td>110 W</td>
<td>80 W</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>0</td>
<td>Same (On Mag. Tape)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>2 Frames/25 sec.</td>
<td>2 Frames/25 sec.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 3. PANORAMIC CAMERA

1) PHYSICAL REQUIREMENTS:
- SIZE: 0.44 m$^3$
- WEIGHT: 129 Kg (283 lb) Space Envr.
- POWER: 234 W. (av.)

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>During eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>234 W</td>
<td>234 W</td>
<td>234 W</td>
<td>160 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>Time, temp, f.p., slit setting, filter, orbit, gimbal angles</td>
<td>Same (Film code block)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>1 frame 11.5 x 128 cm film</td>
<td>1 frame/10 sec. 11.5 x 128 cm film</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1/4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: WIDE ANGLE FRAMING CAMERA (24 x 48 cm film)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.27 m^3 Camera
   - 0.06 m^3 Gimbals
   - WEIGHT: 68.5 Kg (150 lb) Camera
   - 61 Kg (135 lb) Gimbals
   - POWER: 170 W (av) 224 W (pk) Camera
   - 80 W (av) 250 W (pk) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max) (warm-up)</td>
<td>15 min.</td>
<td>10 min.</td>
<td>30 sec./target</td>
<td>Time between targets</td>
<td>During eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>250 W</td>
<td>420 W (pointing)</td>
<td>304 W</td>
<td>250 W</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>Time, temp, f, no, filter, orbit, gimbal angles</td>
<td>Same (film code block)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>1 Frame 24 x 48 cm film</td>
<td>1 Frame 24 x 48 cm film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1/2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
**MISSION ANALYSIS SENSOR DATA BANK**

**SENSOR:** 5. MULTISPECTRAL CAMERA SYSTEM (24 x 24 cm. Film)

**1) PHYSICAL REQUIREMENTS:**

- **SIZE:** 2.0 m$^3$ Cameras
- **WEIGHT:** 760 Kg (1670 lb) Cameras
- **POWER:** 500 W, 2 Cameras

**2) REQUIREMENTS:**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>30 sec/target</td>
<td>Time Between Targets</td>
<td>During Eclipse</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>1 KW (2 Cam.)</td>
<td>2 KW (2 Cam.)</td>
<td>1 KW (2 Cam.)</td>
<td>1 KW (2 Cam.)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2 KW (6 Cam.)</td>
<td>3 KW (6 Cam.)</td>
<td>2 KW (6 Cam.)</td>
<td>2 KW (6 Cam.)</td>
<td></td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>--</td>
<td>Time, Cone Temp.,</td>
<td>2 KW (6 Cam.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lens Setting,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Filter Type, Orbit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gimbal Angles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Film</strong></td>
<td>--</td>
<td>2 or 6 Frames</td>
<td>2 or 6 frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 x 24 cm film</td>
<td>24 x 24 cm film</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manpower</strong></td>
<td>1/3</td>
<td>1/2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Special</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**3) CONFLICTS WITH OTHER SENSORS:**
### SENSOR: 6. HIGH RESOLUTION MULTISPECTRAL CAMERA SYSTEM (70 mm film)

#### 1) PHYSICAL REQUIREMENTS:
- **SIZE:** 0.12 m$^3$ Cameras
- **WEIGHT:** 64 Kg (140 lb) Gimbals
- **POWER:** 60 W (av) 300 W (pk) Gimbals

#### 2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>5 min.</td>
<td>30 sec/target</td>
<td>Time between targets</td>
<td>During eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>160 W (tracking mode)</td>
<td>600 W (tracking mode)</td>
<td>600 W</td>
<td>160 W</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>Time, temp., fno, filter, orbit, gimbal angles</td>
<td>Same (on mag tape)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>Six 70 mm frames</td>
<td>Six 70 mm frames per target</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### 3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 7. MULTiresOLUTION CAMERA SYSTEM (24 x 24 cm film)

1) PHYSICAL REQUIREMENTS:

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 m³ Cameras</td>
<td>380 Kg (835 lb)</td>
<td>250 W (av) 750 W (pk)</td>
</tr>
<tr>
<td>0.21 m³ Gimbals</td>
<td>182 Kg (400 lb)</td>
<td></td>
</tr>
<tr>
<td>Camera</td>
<td>Gimbals</td>
<td></td>
</tr>
</tbody>
</table>

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>30 sec/target</td>
<td>Time between targets</td>
<td>During eclipse</td>
</tr>
<tr>
<td>Power</td>
<td>1 KW</td>
<td>1.5 KW (pointing)</td>
<td>1 KW</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>Time, temp, fno, filter, orbit, gimbal angles</td>
<td>Same (film code block)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>3 frames 24 x 24 cm film</td>
<td>3 frames 24 x 24 cm film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1/2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: HIGH RESOLUTION WIDEBAND MULTISPECTRAL SCANNER

1) PHYSICAL REQUIREMENTS:

- **SIZE**: 0.59 m$^3$ Scanner, 0.09 m$^3$ Gimbals
- **WEIGHT**: 138 Kg (300 lb) Scanner, 64 Kg (140 lb) Gimbals
- **POWER**: 311 W Scanner, 60 W (av) 300 W (pk) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/ Modification</th>
<th>Checkout</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over targets</td>
<td>Time between targets</td>
<td>Over ocean</td>
</tr>
<tr>
<td>Power</td>
<td>371 W</td>
<td>611 W</td>
<td>371 W</td>
<td>311 W</td>
<td>0</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>200 MB/S (2) 33% duty cycle</td>
<td>200 MB/S 33% duty cycle (2)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/3</td>
<td>1</td>
<td>1/4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:

(1) Annotation: Time, instrument temp., gimbal angles, orbit (on mag. tape)

(2) Using 20 spectral bands. Data rate can be reduced by use of only selected spectral bands.
## SENSOR: 9. LONG WAVELENGTH INFRARED SPECTROMETER

### 1) PHYSICAL REQUIREMENTS:
- **SIZE:** 0.31 m³
- **WEIGHT:** 182 Kg (402 lb)
- **POWER:** 200 W (av)

### 2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>15 min. (warm-up)</td>
<td>10 min.</td>
<td>20 sec./target</td>
<td>Time between targets</td>
<td>Over ocean</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>200 W</td>
<td>200 W</td>
<td>200 W</td>
<td>100 W</td>
<td>0W</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>-</td>
<td>6.94 KB/S</td>
<td>6.94 KB/S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Annotation(1)</td>
<td>+ annotation(1)</td>
<td>+ annotation(1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Film</strong></td>
<td>-</td>
<td>16 mm film</td>
<td>16 mm film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Manpower</strong></td>
<td>1/3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Special</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3) CONFLICTS WITH OTHER SENSORS:
- Annotation: Time, instrument temp., gimbal angles, orbit (on mag. tape).
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 10A WIDEBAND SYNTHETIC APERTURE RADAR (WIDE COVERAGE, LOW RESOLUTION MODE)

1) PHYSICAL REQUIREMENTS:

- SIZE: 1.67 m³ (60 ft³)
- WEIGHT: 320 Kg (700 lbs)
- POWER: 1.08 KW

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target area</td>
<td>Time between targets</td>
<td>At completion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>1.1 KW</td>
<td>1.1 KW</td>
<td>1.1 KW</td>
<td>0.2 KW</td>
<td>0W</td>
</tr>
<tr>
<td>Data</td>
<td>-</td>
<td>Housekeeping data on mag. tape</td>
<td>Same</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Film</td>
<td>-</td>
<td>70 mm film</td>
<td>70 mm film</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/2</td>
<td>1/2</td>
<td>1/4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (instruments 32, 33, 34).
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 10B WIDEBAND SYNTHETIC APERTURE RADAR (MEDIUM COVERAGE, HIGH RESOLUTION MODE)

1) PHYSICAL REQUIREMENTS:
   • SIZE: 1.67 m³ (60 ft³)
   • WEIGHT: 320 Kg (700 lb)
   • POWER: 2.2 KW

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>At completion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>2.2 KW</td>
<td>2.2 KW</td>
<td>2.2 KW</td>
<td>0.2 KW</td>
<td>0W</td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td>Housekeeping data on mag. tape</td>
<td>Same</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film</td>
<td></td>
<td>70 mm film</td>
<td>70 mm film</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manpower</td>
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<td>1/2</td>
<td>1/4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (Instruments 32, 33, 34).
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 11A. MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR

1) PHYSICAL REQUIREMENTS: (MEDIUM COVERAGE, LOW RESOLUTION MODE)

- SIZE: \(8.6 \text{ m}^3 (288 \text{ ft}^3)\)
- WEIGHT: 990 Kg (2075 lb)
- POWER: 2 KW

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>10 min. (Warm-up)</td>
<td>10 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>At completion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>2 KW</td>
<td>2 KW</td>
<td>2 KW</td>
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<td>1/2</td>
<td>1/4</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (instruments 32, 33, and 34).
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 11B. MULTIFREQUENCY WIDEBAND SYNTHETIC APERTURE RADAR

1) PHYSICAL REQUIREMENTS: (NARROW COVERAGE, HIGH RESOLUTION MODE)
   - SIZE: 8.6 m³ (288 ft³)
   - WEIGHT: 990 Kg (2075 lb)
   - POWER: 2 KW

2) REQUIREMENTS:

<table>
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<tr>
<th>Requirement</th>
<th>EVENTS</th>
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<tbody>
<tr>
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<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min. (warm-up)</td>
</tr>
<tr>
<td>Power</td>
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<td>Data</td>
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<td>Manpower</td>
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<td>Special</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS: Cannot operate when passive RF equipment is being used (instruments 32, 33, and 34).
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 12. LASER ALTIMETER/SCATTEROMETER

1) PHYSICAL REQUIREMENTS:
- SIZE: 0.05 m³
- WEIGHT: 18 Kg (40 lb)
- POWER: 150 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification (Standard, or Min/Max)</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
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<tbody>
<tr>
<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>At completion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>150 W</td>
<td>150 W</td>
<td>150 W</td>
<td>50 W</td>
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<td>150 B/S</td>
<td>150 B/S</td>
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<td>0 B/S</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 13. VISIBLE IMAGING SPECTROMETER

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.084 m³ (3 ft³)  (3 instruments)
   - WEIGHT: 69 Kg (150 lb)  (3 instruments)
   - POWER: 75 W  (3 instruments)

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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</thead>
<tbody>
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<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>5 min.</td>
<td>Continuous over target</td>
<td>Time between targets</td>
<td>During eclipse and over land masses</td>
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<td>Power</td>
<td>75 W</td>
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<td>378 KB/S (3 instruments)</td>
<td>378 KB/S (3 instruments)</td>
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<td>Film</td>
<td>-</td>
<td>-</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
SENSOR: 19. UV UPPER ATMOSPHERIC SOUNDER (UVUAS)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.01 m³ (0.35 ft³)
   - WEIGHT: 6.8 Kg (15 lb)
   - POWER: 15 W

2) REQUIREMENTS:

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<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<tbody>
<tr>
<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>15 min.</td>
<td>5 min./sighting</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
</tr>
<tr>
<td>Power</td>
<td>10 W</td>
<td>15 W</td>
<td>15 W</td>
<td>10 W</td>
<td>0 W</td>
</tr>
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<td>Film</td>
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<td>-</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 20. VISIBLE RADIATION POLARIMETER (VRP)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.06 m³ (2.0 ft³)
   - WEIGHT: 18 Kg (40 lb)
   - POWER: 20 W (av)
   
85 W (pk)
   12 W (standby)

2) REQUIREMENTS:

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<thead>
<tr>
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<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<tr>
<td>Duration</td>
<td>10 min. (warm-up)</td>
<td>10 min.</td>
<td>2 min./sighting</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
</tr>
<tr>
<td>Power</td>
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<td>45 W</td>
<td>45 W</td>
<td>12 W</td>
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</tr>
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<td>500 B/S</td>
<td>-</td>
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<td>Film</td>
<td>-</td>
<td>-</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
## MISSION ANALYSIS SENSOR DATA BANK

**SENSOR:** 21. AIR POLLUTION CORRELATION SPECTROMETER

### 1) PHYSICAL REQUIREMENTS:
- **SIZE:** 0.028 m$^3$ (1,0 ft$^3$)
- **WEIGHT:** 13.6 Kg (30 lb)
- **POWER:**
  - 15 W (av.)
  - 18 W (pk.)
  - 10 W (standby)

### 2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<tbody>
<tr>
<td><strong>Duration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Standard, or</td>
<td>10 min</td>
<td>10 min</td>
<td>Continuous over</td>
<td>Between sightings and</td>
<td>At end of mission</td>
</tr>
<tr>
<td>Min/Max)</td>
<td>(warm-up)</td>
<td></td>
<td>target area</td>
<td>during eclipse</td>
<td></td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>10 W</td>
<td>18 W</td>
<td>18 W</td>
<td>10 W</td>
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<td><strong>Data</strong></td>
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<td>7 L/S</td>
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<td>---</td>
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<tr>
<td><strong>Film</strong></td>
<td>---</td>
<td>---</td>
<td>---</td>
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<td>---</td>
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<td>1/2</td>
<td>1</td>
<td>0</td>
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</table>

### 3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 22. HIGH SPEED INTERFEROMETER (HSI)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.08 m$^3$ (3.0 ft$^3$) Sensor
   - WEIGHT: 46 Kg (100 lb) Sensor
   - POWER: 150 W Sensor
   - 0.04 m$^3$ (1.5 ft$^3$) Gimbals
   - 23 Kg (50 lb) Gimbals
   - 100 W (pk), 30 W (av) Gimbals

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/ Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>15 sec/target</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
</tr>
<tr>
<td>Power</td>
<td>180 W</td>
<td>250 W (w-axis pointing)</td>
<td>250 W (2-axis pointing)</td>
<td>30 W</td>
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<td>20 KIL/S</td>
<td>20 KIL/S</td>
<td>---</td>
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<td>Film</td>
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<td>Manpower</td>
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<td>1</td>
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<td>Special</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
**MISSION ANALYSIS SENSOR DATA BANK**

**SENSOR:** 23. CARBON MONOXIDE POLLUTION EXPERIMENT (COPE)

1) **PHYSICAL REQUIREMENTS:**
- SIZE: 0.04 m³ (1.21 ft³)
- WEIGHT: 20.5 K₃ (45 lb)
- POWER: 20 W (av.)
  - 35 W (pk.)
  - 10 W (standby)

2) **REQUIREMENTS:**

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<th>Set Up/Modification</th>
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<th>Operate</th>
<th>Standby</th>
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<tbody>
<tr>
<td>Duration</td>
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<td>10 min</td>
<td>Continuous (Nadir - viewing)</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
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<td>Data</td>
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<td>1.2 K₂/S</td>
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</table>

3) **CONFLICTS WITH OTHER SENSORS:**
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 24. CLOUD PHYSICS RADIOMETER (CPR)

1) PHYSICAL REQUIREMENTS:
- SIZE: 0.043 m³ (1.5 ft³)
- WEIGHT: 32 Kg (70 lb)
- POWER: 40 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>Continuous over target area</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
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<tr>
<td>Power</td>
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3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 25. REMOTE GAS FILTER CORRELATION ANALYZER (RGFCA)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.012 m³ (0.42 ft³)
   - WEIGHT: 14 Kg (30 lb)
   - POWER: 7 W (av.)
   - 10 W (pk)

2) REQUIREMENTS:

<table>
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<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>Continuous over target area</td>
<td>Between sightings</td>
<td>At conclusion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>7 W</td>
<td>10 W</td>
<td>10 W</td>
<td>7 W</td>
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<td>3.6 KB/S</td>
<td>3.6 KB/S</td>
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3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 26. ADVANCED LIMP RADIANCE INVERSION RADIOMETER (ALRIR)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.034 m³
   - WEIGHT: 16.4 Kg (36 lb)
   - POWER: 81 W

2) REQUIREMENTS:

<table>
<thead>
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<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>5 min/sighting (horizon)</td>
<td>Between sightings and during eclipse</td>
<td>At end of mission</td>
</tr>
<tr>
<td>Power</td>
<td>81 W</td>
<td>81 W</td>
<td>81 W</td>
<td>20 W</td>
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<td>Film</td>
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</tr>
<tr>
<td>Manpower</td>
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3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 27. TIROS-N ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

1) PHYSICAL REQUIREMENTS:
- SIZE: 0.049 m³ (1.8 ft³)
- WEIGHT: 20 Kg (43 lb)
- POWER: 70 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>Continuous over target area</td>
<td>Between sightings</td>
<td>At conclusion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>70 W</td>
<td>70 W</td>
<td>70 W</td>
<td>30 W</td>
<td>0 W</td>
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<td>1.12 KB/S</td>
<td>1.12 KB/S</td>
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</table>

3) CONFLICTS WITH OTHER SENSORS:
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 28. TIROS-N OPERATIONAL VERTICAL SOUNDER (TOVS)

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.041 m³ (1.46 ft³)  •  WEIGHT: 47 Kg (101 lb)  •  POWER: 73 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
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<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>Continuous over target area</td>
<td>Between sightings</td>
<td>At conclusion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>73 W</td>
<td>73 W</td>
<td>73 W</td>
<td>25 W</td>
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</tr>
<tr>
<td>Data</td>
<td>---</td>
<td>3 KB/S</td>
<td>3 KB/S</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Film</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Manpower</td>
<td>1/2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
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</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
 SENSOR: 29. **PASSIVE MULTICHANNEL MICROWAVE RADIOMETER (PMMR)**

1) **PHYSICAL REQUIREMENTS:**

- **SIZE:** 5.45 m$^3$ (58.5 ft$^3$)  
- **WEIGHT:** 230 Kg (513 lb)  
- **POWER:** 355 W

2) **REQUIREMENTS:**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>EVENTS</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Set Up/Modification 1</td>
</tr>
<tr>
<td></td>
<td>Checkout Calibration 2</td>
</tr>
<tr>
<td></td>
<td>Operate 3</td>
</tr>
<tr>
<td></td>
<td>Standby 4</td>
</tr>
<tr>
<td></td>
<td>Shut Down 5</td>
</tr>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
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<tr>
<td>Power</td>
<td>355 W</td>
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<tr>
<td>Data</td>
<td>---</td>
</tr>
<tr>
<td>Film</td>
<td>---</td>
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<tr>
<td>Manpower</td>
<td>1/2</td>
</tr>
<tr>
<td>Special</td>
<td>1</td>
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</table>

3) **CONFLICTS WITH OTHER SENSORS:** Cannot be used simultaneously with active radar.
**MISSION ANALYSIS SENSOR DATA BANK**

**SENSOR:** 30. MICROWAVE RADIOMETER/SCATTEROMETER

1) **PHYSICAL REQUIREMENTS:**
   - SIZE: $1.4 \text{ m}^3$ (50 ft$^3$)
   - WEIGHT: 310 Kg (680 lb)
   - POWER: 330 W

2) **REQUIREMENTS:**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min (warm-up)</td>
<td>10 min</td>
<td>Continuous over target area</td>
<td>Between sightings</td>
<td>At conclusion of experiment</td>
</tr>
<tr>
<td>Power</td>
<td>330 W</td>
<td>330 W</td>
<td>330 W</td>
<td>40 W</td>
<td>0 W</td>
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<tr>
<td>Data</td>
<td>---</td>
<td>80 B/S</td>
<td>80 B/S</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Film</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Manpower</td>
<td>1</td>
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<td>1/2</td>
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</tr>
<tr>
<td>Special</td>
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</tbody>
</table>

3) **CONFLICTS WITH OTHER SENSORS:**
MISSION ANALYSIS SENSOR DATA BANK

SENSOR:  31. SFERICS RECEIVER

1) PHYSICAL REQUIREMENTS:
   • SIZE: 0.35 m$^3$ (11.7 ft$^3$)
   • WEIGHT: 32.3 Kg (71 lb)
   • POWER: 60 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>10 min. (warm-up)</td>
<td>10 min.</td>
<td>Continuous over target area</td>
<td>Between sightings</td>
<td>At conclusion of experiment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Power</th>
<th>Data</th>
<th>Film</th>
<th>Manpower</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement</td>
<td>60 W</td>
<td>780 B/S</td>
<td>---</td>
<td>1</td>
<td>---</td>
</tr>
<tr>
<td>Requirement</td>
<td>60 W</td>
<td>780 B/s</td>
<td>---</td>
<td>1/4</td>
<td>---</td>
</tr>
<tr>
<td>Requirement</td>
<td>30 W</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>Requirement</td>
<td>0 W</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>---</td>
</tr>
</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS: Cannot be used simultaneously with active radar.
MISSION ANALYSIS SENSOR DATA BANK

SENSOR: 32. WIDE ANGLE VIEWER/HYDROGEN ALPHA LINE VIEWER

1) PHYSICAL REQUIREMENTS:
   - SIZE: 0.106 m³ (3.8 ft³)
   - WEIGHT: 25 Kg (55 lb)
   - POWER: 10 W

2) REQUIREMENTS:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (Standard, or Min/Max)</td>
<td>5 min.</td>
<td>5 min</td>
<td>1 min./target</td>
<td>Between sightings</td>
<td>At conclusion of experiments</td>
</tr>
<tr>
<td>Power</td>
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<td>30 W</td>
<td>30 W</td>
<td>0 W</td>
<td>0 W</td>
</tr>
<tr>
<td>Data</td>
<td>---</td>
<td>---</td>
<td>Real-time TV display</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Film</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Manpower</td>
<td>1</td>
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<tr>
<td>Special</td>
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</tbody>
</table>

3) CONFLICTS WITH OTHER SENSORS:
## Mission Analysis Sensor Data Bank

**Sensor:** 33. Data Collection System

### 1) Physical Requirements:
- **Size:** 0.035 m$^3$ (1.24 ft$^3$)
- **Weight:** 14.2 kg (31 lb)
- **Power:** 92 W

### 2) Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Set Up/Modification</th>
<th>Checkout Calibration</th>
<th>Operate</th>
<th>Standby</th>
<th>Shut Down</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>10 min. (warm-up)</td>
<td>0</td>
<td><strong>Operate</strong></td>
<td>Continuous over target area (240 min capacity)</td>
<td>Between data collection intervals</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>92 W</td>
<td>0</td>
<td>92 W</td>
<td>0 W</td>
<td>0 W</td>
</tr>
<tr>
<td><strong>Data</strong></td>
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<td>---</td>
<td>30 KHz on each of 5 tracks (240 min. capacity)</td>
<td>---</td>
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</tr>
<tr>
<td><strong>Film</strong></td>
<td>---</td>
<td>---</td>
<td>---</td>
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<tr>
<td><strong>Special</strong></td>
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</tr>
</tbody>
</table>

### 3) Conflicts with Other Sensors:

1. Transfers data to ground station in 6 minutes at 240 KHz bandwidth.
### Instrument: 18

#### COMMENTS:
- This matrix represents a nighttime cycle only. During daylight the instrument is in event 4.
- The instrument is only sequenced through the events once every other day. During off days the instrument is in event 5.
- Events 1 and 2 occur once every 2 days, 30 minutes prior to the first nighttime period.
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 2 and event 3
  - There is time between targets
- Event 5 occurs at the end of every other day after the last event 3.

<table>
<thead>
<tr>
<th>FIRST EVENT</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>X</td>
<td>X</td>
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</tr>
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<td></td>
<td>X</td>
<td>X</td>
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<td>5</td>
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<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

| SECOND EVENT |
|--------------|---|---|---|---|---|
| 1            |   |   |   |   |   |
| 2            | X | X | X |   |   |
| 3            |   | X | X |   |   |
| 4            |   |   |   | X |   |
| 5            |   |   |   |   | X |
**Instruments:** 19, 20, 21, 22, 23, 24, 26

**Comments:**

- This matrix represents the daylight cycle only. During eclipse the instrument is in event 4.

- Event 2 occurs once every day (minimum separation between repeats - 8 hours).

- Event 1 occurs once at the beginning of the mission.

- Event 5 occurs once at the end of the mission after the last event 3.

- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3.
  - There is time between targets.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tr>
<td><strong>3</strong></td>
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<td>X</td>
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</tr>
<tr>
<td><strong>4</strong></td>
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Instruments: 13, 15

<table>
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</tbody>
</table>

**COMMENTS:**
- Event 1 occurs once at the beginning of the mission
- Event 2 occurs once every two hours
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets
- Event 5 occurs after the last event 3.
**Instruments:** 12, 17

## COMMENTS:

- Events 1 and 2 occur once, in sequence, at the beginning of the mission.
- Event 4 occurs prior to or after event 3 if:
  - There is time between events 2 and 3
  - There is time between targets
- Event 5 occurs after the last event 3.

<table>
<thead>
<tr>
<th>First Event</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
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**Instruments:** 29, 30, 31

**SECOND EVENT**

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<th>4</th>
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<td>5</td>
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</tr>
</tbody>
</table>

**COMMENTS:**
- Event 2 occurs once every day (minimum separation between repeats - 8 hours)
- Event 1 occurs once at the beginning of the mission
- Event 5 occurs once at the end of the mission after the last event 3
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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</tr>
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<tbody>
<tr>
<td><strong>C-36 FIRST EVENT</strong></td>
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</tr>
</tbody>
</table>

**SECOND EVENT**

**COMMENTS:**

- Event 2 follows event 1 once a day. Minimum separation between repeats of event 2 is 8 hours.
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is time between targets
- Event 5 occurs after the last event 3

Instruments: 3, 9, 10A, 10B, 11A, 11B, 14, 16, 25, 27, 28
- This matrix represents the daylight cycle only, the instrument is shut down during eclipse
- Event 2 follows event 1 once every two days
- Event 4 occurs prior to or after event 3 if:
  - There is time between event 1 or event 2 (if performed) and event 3
  - There is a target left to be covered before eclipse, after the last event 3
- Event 5 is followed by event 1, 5 minutes prior to daylight
APPENDIX D

AESOP OUTPUT TIMELINES

- EXPERIMENTS
- SENSORS
- POWER
APPENDIX D

AESOP OUTPUT TIMELINES

The output of AESOP consists of experiment schedules and resources summaries (timelines and tabular summaries). This Appendix shows the following outputs:

- Experiment timeline
- Sensor utilization timeline
- Power utilization timeline

Each timeline is two days in length because a coverage cycle in the pollution reference mission is that long (i.e., the time history will repeat every 48 hours).
EXPERIMENT/SENSOR TIMELINE
FOR THE FIRST TWO-DAY CYCLE
OF THE FIVE-DAY BASELINE POLLUTION MISSION
Iy kzz Oi WAR X G 1 2 3 4 5 6 7 8 9 DE m 11 E a 19 20 y 21 22 23 25 26 27 28 29 30 31 32 33 7 24.75 of on TIME FROM LAUNCH (HOURS) 24.75 24.80 25.85 26.00 26.05
TIME FROM LAUNCH (HOURS)

01  M4  OT3  G4/AFR3  02  E2

D-6

SENSORS

1  2  3  4  5  6  7  8  9  10A  11A  12  13  14  15  16
POWER TIMELINE

FOR THE FIRST TWO-DAY CYCLE

OF THE FIVE-DAY BASELINE POLLUTION MISSION