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NASA CR-112331

EARTH ORBITAL EXPERIMENT PROGRAM

AND

REQUIREMENTS STUDY

Volume 7

SUPPORTING TECHNOLOGY DEVELOPMENT

REQUIREMENT DESCRIPTIONS

(Appendix E)

Prepared under Contract No. NAS1-9464 by
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for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(NASA-CR-112331) EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY. VOLUME 7: SUPPORTING TECHNOLOGY DEVELOPMENT REQUIREMENT DESCRIPTIONS (McDonnell-Douglas Corp.) 519 p HC $28.00 CSCL 22A

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FOREWORD

The information presented in this report summarizes three major steps toward production of a reference manual for planners of manned earth-orbital research activity. The reference manual will serve as one of the principal tools of a systems approach to experiment and mission planning based on an integrated consideration of candidate research programs and their attendant vehicle, mission, and technology development requirements.

The first major step toward preparation of the manual was the development of long-range goals and objectives suitable for NASA's activities during the 1970-1980 time period. This work was completed by NASA Headquarters with active center support and was published in September 1969 as a portion of a report for the President's Space Task Group entitled, "America's Next Decade in Space."

The second major step was a contractual study effort undertaken in September 1969 by McDonnell Douglas Astronautics Company-West with the TRW Systems Group, the IBM Federal Systems Division, and the RPC Corporation. The purpose of the study was to structure the NASA-developed goals and objectives into an orderly, system-oriented set of implementation requirements. The contractor examined, in depth, the orbital experiment program required to achieve the scientific, technological, and application objectives, and determined in a general way the capabilities required in future manned orbital programs to accommodate the defined experiments. Thus, the basic task of the contractor was to aid NASA in studying the useful and proper roles of manned and automated spacecraft by examining the implementation alternatives for NASA experiments.

The third major step presented in this document is the result of an integrated consideration of NASA's long-range goals and objectives, the system and mission requirements, and the alternative implementation plans. It will serve as a source of detailed information and methodology for use by NASA planners in development and justification of future programs.

Management

Technical direction (fig. 1) of the contracted study effort is the responsibility of the Advanced Aerospace Studies Branch (AASB) of the Space Systems Division (SSD) at the Langley Research Center (LRC). Technical guidance is provided by the Earth Orbital Experiment Program Steering Group which reports through the Planning Steering Group (PSG) to the Associate Administrator. Technical coordination is also maintained with appropriate personnel at ARC, GSFC, MSC, and MSFC.

The membership of the Steering Group (fig. 2) comprises representatives of the working groups of the PSG under the chairmanship of Dr. R. G. Wilson, Director, Advanced Programs, OSSA. The NASA Study Management Team is headed by Mr. W. R. Hook of the AASB. Technical support is supplied by elements of the Langley Research Center as required.

The contractor's Study Team is headed by Dr. H. L. Wolbers, MDAC, and the Senior Management Review Council is chaired by Mr. C. J. Dorrenbacher, Vice President, Advanced Systems and Technology, MDAC.

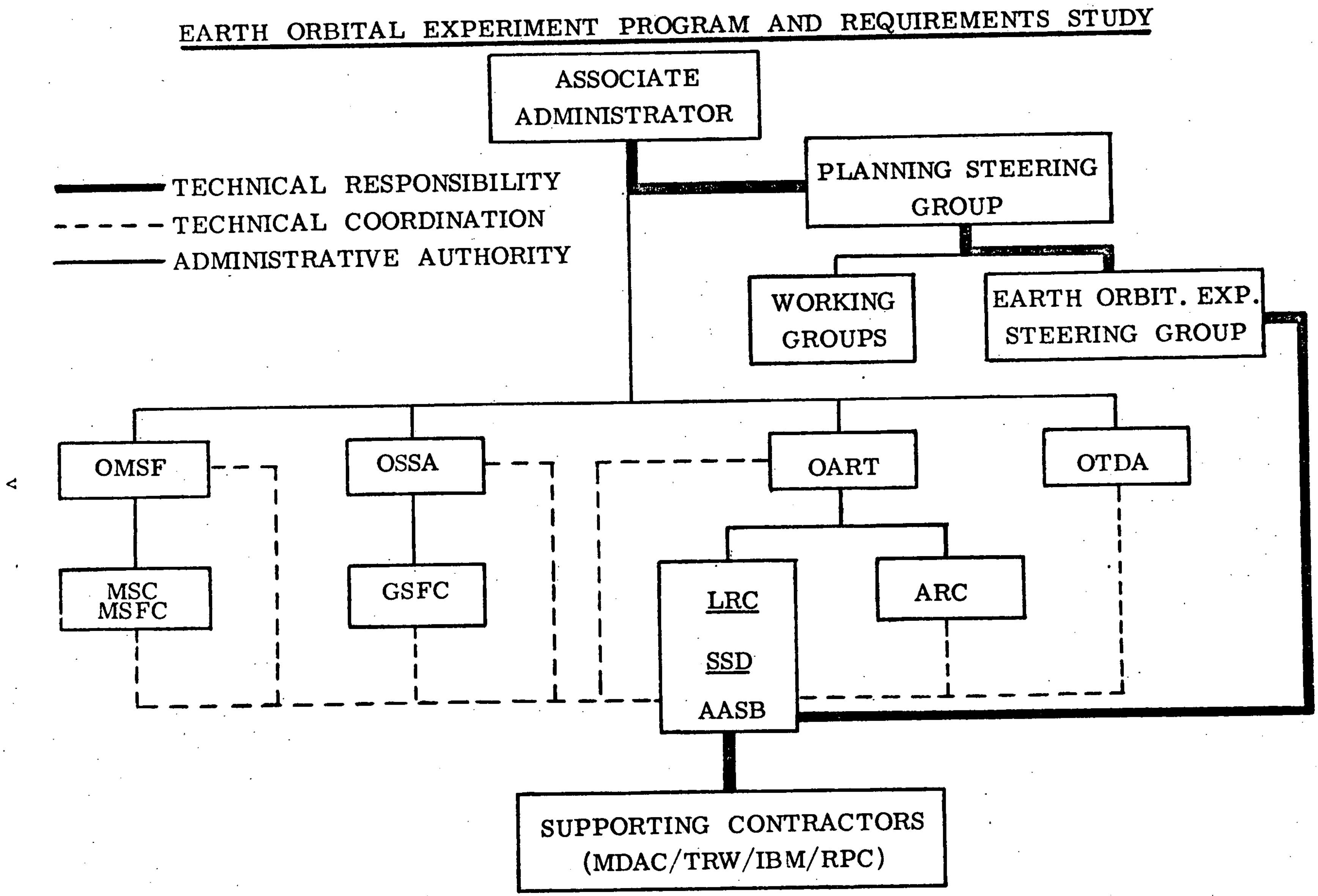

Figure 1.- Management Plan.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

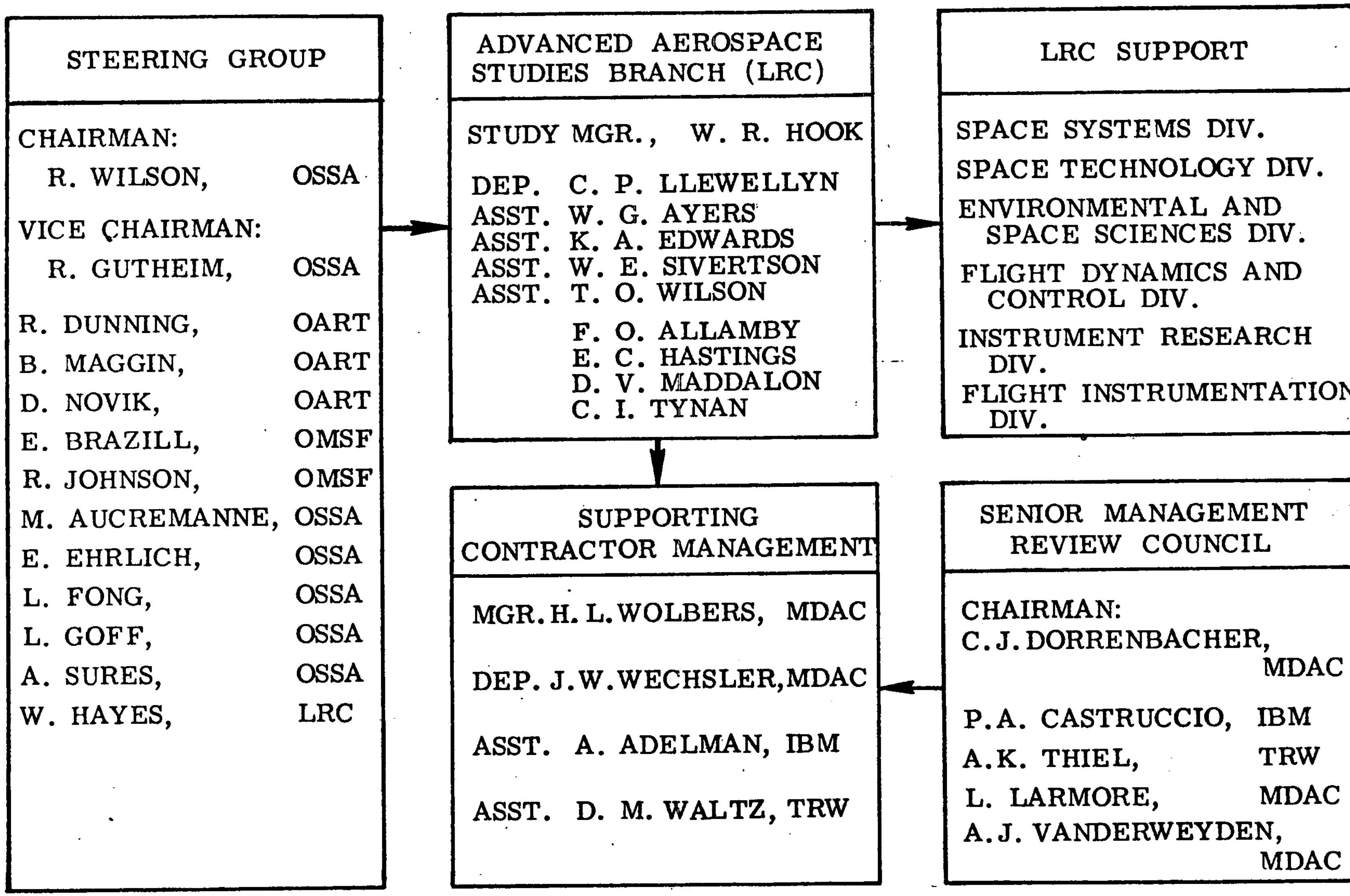

Figure 2. - Study Team.

APPENDIX E

SUPPORTING TECHNOLOGY DEVELOPMENT REQUIREMENT DESCRIPTIONS

APPENDIX E

Preface

The requirement description for supporting technology development (STD) are presented in this appendix. The format used to document these STD items is the same as discussed in Section 6 and in the following outline:

- Item 1 - Presents a short title of the STD requirement.
- Item 2 - Presents a brief description of the STD requirement.
- Item 3 - Lists the research cluster from which STD was derived.
- Item 4 - Lists the item number in the research cluster or synopsis from which STD was derived. (For the sake of brevity, some of the reference data is not included in this report; however, where this item references "synopsis," the data can be found in Appendix C).
- Item 5 - Defines whether the technology development effort required is a study, experiment (in space, not in space), and/or development activity.
- Item 6 - Defines whether the objective of the technology development is an advancement in theory, component capability, system capability, and/or operations methods.
- Item 7 - States the technology required by the research cluster (items 3 and 4).
- Item 8 - States the present state-of-the-art relative to the requirements in item 7.
- Item 9 - Defines whether the STD is critical or important (critical - if some experimental results are unattainable. Important - if some experimental results will be degraded or too costly).
- Item 10 - Lists other STD items with which this STD requirement could be integrated.
- Item 11 - Defines the approach required to achieve the technology advancement (if known).
- Item 12 - Defines special laboratory or support facilities required.
- Item 13 - States any known ongoing activities which could be integrated with this STD requirement.
- Item 14 - Estimates the time required to achieve this advancement.
- Item 15 - Estimates the cost required to achieve this advancement.
- Item 16 - Estimates the level of confidence in achieving this advancement.

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STD No.	STD Title	
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STD No.	STD Title
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EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Inflight Body Fluid Analysis

2. BRIEF DESCRIPTION. A study to define techniques and procedures for the conduct of inflight body fluid analysis.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-10

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System, Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. In order to conduct fluid analysis in space, the following techniques and operations must be defined: 1) fluid handling and transfer techniques for both laboratory manipulation of fluids and the operation of gravity dependent analytical equipment; 2) the definition of which analyses should be performed onboard and which should be performed only on returned samples; 3) adaptation of terrestrial laboratory equipment for spaceflight use including weight, power, and volume reductions, operation in zero-g, and simplicity of operation for use by spacecraft crewmen; 4) automation of operation for a broad spectrum of the determinations to be performed onboard.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. 1) All present fluid handling techniques are gravity dependent; IMBLMS and associated programs are giving the problem some consideration. 2) Some analyses are so difficult that only a few laboratories in the country perform them; all

potential determinations should be evaluated for onboard measurement. 3) IMBLMS program is performing this study for some equipment items. 4) Automatic operations presently available in large analytical laboratories; this type of equipment should be evaluated for spacecraft use.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-5, B-13, and B-21.

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. IMBLMS

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Non-Invasive Venous Pressure Measurement

2. BRIEF DESCRIPTION. Non-invasive central venous pressure measurement technique.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-4

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory; Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Non-invasive method for central, not peripheral, venous pressure measurement.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current technique is cardiac cathertization. No current IMBLMS activity exists to meet this requirement; hence, a separate activity is required.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Theory and development study first. No special facilities required.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. No known ongoing activity.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Low

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Animal Toxicological Chamber

2. BRIEF DESCRIPTION. Small animal toxicological exposure chamber for spacecraft use.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-5

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A small chamber is required, capable of maintaining specified levels of toxic contaminants for varying lengths of time for exposure of groups of small animals.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Such chambers are available in terrestrial laboratories, but gross modification would be necessary for spacecraft use. Their weight and volume, power requirements, and methods for presenting toxics are not compatible with orbiting spacecraft usage.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Modification of current chambers for space use with development testing in space.

12. SPECIAL FACILITIES REQUIRED. Ground and space laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None known

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Manned Orbital Animal Research Facility

2. BRIEF DESCRIPTION. Manned Orbital Animal Research Facility (MOARF), including animal housing, environmental control and life support systems, and waste management.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-5

4. ITEM NO(S). 50, Synopsis, Para. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Details have been described in the MOARF studies. Animal housing facilities should be at slightly lower pressures than the rest of the space station to minimize interchange of environments. There is need in the weightless environment for such items as new types of waste management compatible with animal size and experiment needs, new types of food and water dispensing, and self-contained air conditioning systems (ECS) separate from what is used for man. Requirements will vary with experiment needs, and level of development will vary accordingly.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Facilities exist on Earth. Some analytic work and study of needs in space has been described in CRAD -- Manned Orbital Animal Research Facility (MOARF) studies supported by OART, Hdq. NASA. Earth facilities utilize gravity for waste management and for holding water and food in dispensers. The air conditioning systems freely exchange inside and outside air. These are examples of practices incompatible with a manned orbital animal research facility.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-BM-12, Studies on Instrumented Animals. STD BM10 titled "Animal Experiment Modules".

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Laboratory, non-space and space.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MOARF studies, Bio-satellite, Biotechnology Laboratory.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Radiation Source

2. BRIEF DESCRIPTION. Radiation source for animal radiation experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-5

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. X-ray unit capable of administering radiation doses (whole body radiation) of 25, 50, 100, 300, and 400 REM to groups of animals. If possible it should be combined with a diagnostic x-ray unit. A study is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Portable units exist today for diagnostic purposes, but their adaptability for multi-purpose use in space is not known.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Heart size - 1-BM-4

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Bone density experiments for Skylab B: the time course of changes in bone density and the effects of exercise on the changes; the relationship of changes in the density of various bones with changes in calcium balance.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

STD ITEM
NO. BM-6

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Space Thermal Enclosure

2. BRIEF DESCRIPTION. Inflight hyperthermia testing chamber or thermal enclosure.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-6

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments, not in space, to define present capabilities

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Temperature range capabilities - 21° C to 80° C ± 2° C; humidity range capabilities - 10% to 70% RH ± 2%; thermal enclosure required which is capable of holding a subject under resting and working conditions with temperature and humidity conditions cited above.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Onboard pressure suit may meet the requirements of this experiment, but ground experimentation is required to evaluate this capability.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Conduct pre-cursor experiments to determine space suit suitability. Follow this with development activity if required.

12. SPECIAL FACILITIES REQUIRED. Ground laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sensitive Quantitative Evaluation of Reflex Functions

2. BRIEF DESCRIPTION. Investigation of methods for more sensitive quantitative evaluation of the reflex functions.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). I-BM-7

4. ITEM NO(S). 31

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments, not in space, to define present capabilities

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Quantitative reflex function measurement instruments are required for orbital use when testing for the subtle functional degradations anticipated with extended stay in zero gravity. A desirable characteristic would be that these new instruments would be more simple to operate and score than today's pathological test procedures which require administration and subjective evaluations by an attending physician.

   EXAMPLE: Electromyogram (leads and preamp) being developed under IMBLMS needs space qualification -- measures electrical activity in muscle fibers associated with muscular contraction. Correlation of the intensity of muscle contraction as represented by the electromyogram tracing and leg movement as sensed by on-body accelerometer with the amplitude and briskness of elicited deep tendon reflexes is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present methods are not sufficiently quantitative for the evaluation of the anticipated subtle changes of reflexes in space. Ground investigation of new methods is required.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-MM-2, STD MM-4

11. SUGGESTED DEVELOPMENT APPROACH(ES). Suggested intrumentation for deep tendon reflex measurement: miniature accelerometers placed on the lower leg and foot for transmitting magnitude and duration of reflex movement. A component for placement and strength of stimulus blow also must be developed. Trigeminal nerve stimulus source could be similar to laboratory apparatus used for eyelid conditioning experiments. Abdominal reflexes could use electromyogram.

12. SPECIAL FACILITIES REQUIRED. Ground laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$150,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

STD ITEM
NO. BM-8

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Endoradiosonde

2. BRIEF DESCRIPTION. Further development of endoradiosonde technique.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). I-BM-8

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments, not in space, to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING TECHNOLOGY, OR OPERATIONAL CAPABILITY. Ingestible device with self-contained radio transmitter capable (1) of sensing intraluminal pressures and pH, and (2) of providing estimates of mobility and position by means of receiver tracking following ingestion. The operation of the instrument should be simple to permit use by a cross-trained crew member.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Instrument now exists but operation is difficult and imprecise.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT.
High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Animal Sensors

2. BRIEF DESCRIPTION. Experimental package of sensor development and use for supporting studies on instrumented animals in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-12

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The various sensors discussed in this experiment group such as electromagnetic flow meters, pressure transducers, vascular occlusive cuffs, ECG and EEG electrodes, brain electrodes, exist and are presently being used in terrestrial laboratories. Their use under the particular circumstances of the experiment, however, must be investigated. In the development of each individual experiment the following questions must be answered: (1) Will the sensors require any modification for use in the desired experiments? (2) What is the maximum in number and in kinds of sensors that can be implanted in a single animal before the physiological condition of the animal is compromised? (3) Is the functional life of the implanted sensor compatible with the required experiment duration.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The various sensors discussed in this experiment group are presently used in terrestrial laboratories, but their application under the particular circumstances of these space experiments must be investigated.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-BM-5, STD BM4

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground laboratories

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MOARF, Biotechnology Laboratory, Biosatellite.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1,000,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Animal Modules

2. BRIEF DESCRIPTION. Animal experiment modules to support studies on instrumented animals in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-12

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The module housing the animals would have to be designed for the particular needs of each individual experiment. Existing modules would probably be used as a point of departure for the new designs.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Modules exist in terrestrial laboratories, but their weight volume, power requirements, and methods for handling food, water, atmosphere, and wastes are not compatible with the weightless state.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-BM-5, STD #BM4

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MOARF studies, Biosatellite, Biotechnology Laboratory, Orbiting Primate Experiment.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5,000,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Body Volumeter

2. BRIEF DESCRIPTION. Development of a body volumeter for use in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED.

3. RESEARCH CLUSTER(S). 1-BM-14

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The body volumeter for space use must isolate or contain the liquid or gas used in the comparative volume measurement so it does not contaminate the spacecraft atmosphere. Other requirements will include control over microorganism growth/transmittal in that medium.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The derivation of lean body mass and adipose tissue mass from body density (mass and volume) is a standard technique. The most common method of measuring body volume in the laboratory is the measurement of water displaced by the immersed body. The terrestrial volumeter that is used depends upon gravity to control the containment of water, its movements and measurement.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). The subject could be enclosed in a container of accurately known volume into which a mass of helium is injected. Then body volume could be derived from sampling and measuring the partial pressure of helium in the gas mixture of the container $(PV=nRT)$.

12. SPECIAL FACILITIES REQUIRED. Small laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Measurement of Transpulmonary Pressure

2. BRIEF DESCRIPTION. The development of a method and equipment for the measurement of transpulmonary pressure to supplant the use of esophageal balloon.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BM-13

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Determinations of lung compliance and pulmonary resistance require the continuous measurement of transpulmonary pressure during changes in lung volume and respiratory flow; an accurate, easily administered, non-objectional method is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Present methods for measuring transpulmonary pressure involve the use of an intrapleural needle or an esophageal balloon. The first is an invasive technique not suitable for spacecraft use; the second is unpleasant and has low subject acceptance. A new method would be of significant value not only in space but also in terrestrial laboratories.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-Based Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Possible Undergoing Study in Association with IMBLMS Programs

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Hearing

2. BRIEF DESCRIPTION. Data describing the effect of physiological deconditioning (in simulated zero gravity) on hearing.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-1-2

4. ITEM NO(S). 29

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Theory; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Understanding of past physiological and psychological space experiences should be known by experimenters. Losses of body fluids, tissue, and bone have been experienced in space. The possibility that loss is differential among bones of skeletal structure has not been determined. For example, is bone demineralization at the same rate for the ossicles (smallest bones in the body and utilized in hearing) as for the long bones of the leg? If loss is specific to the legs or one-gravity load-bearing members, ossicles will not demineralize. Hearing will not change. Simulation bedrest-type studies on Earth should be used to gather preliminary data. Man's hearing capabilities are affected by both the acoustic environment and by man's own physiological state of well being. Any attempt to assess the effect of one factor cannot disregard the interaction of the other, and both factors will be present in space. Information must be gathered on the effect of demineralization on audition when other stresses (e.g., from the acoustic environment) are held constant. This information will be used when evaluating orbital data which describes changes in the astronaut's auditory performance.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Astronauts' hearing has been adequate for meeting operational mission requirements in the short-term spaceflights that have taken place. Data on apparent anklebone demineralization and results presented in urinalysis data are in conflict with the theory of homogeneous demineralization of the skeletal structure.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-BM-5 Blood and Urine, 1-BM-9 Musculoskeletal Function

11. SUGGESTED DEVELOPMENT APPROACH(ES). See Item 7, Bedrest and neutral buoyance simulation of zero-gravity stress can be used.

12. SPECIAL FACILITIES REQUIRED. Earth research facilities readily available in university and industrial settings.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Radiologists' work at Denton, Texas for the NASA.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 if combined with other simulated weightlessness experiments

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Audio Tone Source

2. BRIEF DESCRIPTION. Audio Tone Source -- to measure changes in ability to localize the source of sounds.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-1-2

4. ITEM NO(S). 51

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory of use well established. Need to develop a self-administerable test with preprogrammed changes in location of sound source and qualify equipment for space use.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Understanding, technology, and operational capability present no problems. Present methods utilize manual movements of speaker by a test administrator during measurements.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Incorporate into IMBLMS

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Requires an area of freedom of movement behind test subject of approximately 8' X 8' to permit movement of tone source.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Best to incorporate into the IMBLMS equipment, but initial development could be funded separately.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year for initial development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for initial development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Psychomotor Tests in Simulated Zero-G

2. BRIEF DESCRIPTION. Earth bedrest or immersion types of zero-g simulation to obtain normative data, describing psychomotor performance degradations in weightlessness. Then obtain pre-launch benchmark data of astronaut performance on these tasks to compare to inflight performance.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-1-3

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Experimenters need familiarity with past and planned future space psychomotor activities. Physiological deconditioning has been observed in past spaceflights. That deconditioning should be reproduced via bedrest immersion simulation facilities on Earth to obtain normative data describing psychomotor performance degradation, then space-type psychomotor activities accomplished to estimate the effect of deconditioning on performance.

   Astronauts should accomplish these same activities prior to launch so a benchmark of 1 G-conditioned-astronaut performance is available for comparison to 0-gravity deconditioned astronaut performance.

   This change in performance will become spacecraft design criteria information for use when designing equipment and systems for extended spaceflight.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Astronaut performances have been adequate for meeting operational mission requirements, but psychomotor reaction to weightlessness for periods in excess of two weeks is not available. Both astronauts and cosmonauts have had to accomplish contingency mode re-entry activities because of automated system failures. Information on performance following extended flight is needed for design of systems and equipment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BR7

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Neutral buoyancy and/or bedrest facilities to simulate weightlessness for extended periods.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cognitive Measurements Test Module

2. BRIEF DESCRIPTION. Development of a Cognitive Measurements Test Module having capability for presentation of visual and auditory stimuli to experimental subjects in space, permitting subjects to make responses directly to the module, and scoring the subject's responses. This requires integration of three types of supporting technology: test construction, software development, and hardware development.

3. RESEARCH CLUSTER(S). 1-BR-1-4

4. ITEM NO(S). 3

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. For effective test construction an understanding is needed of the appropriate cognitive test content for the populations of interest in space study (astronauts and scientists) and the methodology available (or which can be developed) to convert such content for computer generation and display. Advanced technology is required in order to develop hardware which integrates a number of different cognitive tests having different modes of stimulus presentation and different modes of subject response (e.g., presentation of different visual patterns both black and white and in color; presentation of speech patterns in both a normal and impoverished mode; responses to stimuli in terms of control activation, keyboard entries, writing, shorthand or coded notation, and voice.).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Cognitive capability and training-needs tests have a long history of successful Earth applications but have not been written in space language. Historical spacecraft, mission, and communications data are available to provide that kind of test content.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). See Item 8; test construction activity by aptitude test construction specialists.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS progr

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One year for study and initial development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200, 000 for test construction; $400, 000 for software and hardware development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Automated Behavior Data from Video and Audio Records.

2. BRIEF DESCRIPTION. Development of techniques and instrumentation for automated extraction of useful crew-behavior data from video and audio records.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-2

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments not in space to define present capabilities; Development

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. In the synopsis, the Paragraph 1 objective requires inflight measurement and evaluation of verbal and physical interactions. However, crew personnel involvements will almost negate their ability to serve as objective observers, so automated procedures are highly desirable.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Behavioral research in terrestrial laboratories has included the gathering of group audio and video data, but through more liberal use of manpower than is feasible aboard spacecraft. Rather analytic parameters have been used to describe the data, and generally the analyses have been accomplished following completion of the experimental phase of research.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BR6

11. SUGGESTED DEVELOPMENT APPROACH(ES). Accomplish sampling studies to optimize data load; explore "Visible Speech" and computer programs to automate the analyses.

12. SPECIAL FACILITIES REQUIRED. Space simulation laboratory, computer capabilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Space cabin simulator 90-day run; Sea-lab research program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three years for study and non-space experiment phases

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000 for study and non-space experiment phases.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Verbal Behavior Assessment Program

2. BRIEF DESCRIPTION. Experimental work relating verbal behavior assessment program to currently available measurements of adjustment. Evaluation of open line space/ground crew communications for meeting verbal behavior assessment data requirements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-2

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. In the synopsis, the Paragraph 1 objective requires inflight measurement and evaluation of verbal and physical interactions. Paragraph 3 states the need for verbal and physical interactions, crew mood data, and crew questionnaire responses. Preliminary experiments are needed for normative and correlation data on these parameters. Further preliminary validation is needed on the use of verbal and visual data, gathered on a non-interference basis, as measures of adjustment, and application of communications to fellow astronauts, family, doctor, priest, as remedial aids to adjustment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Behavioral research in terrestrial labs has included the use of standard personality scales as measures of adjustment and the gathering of verbal and visual observation data. The correlation of these data with openline data to those observers outside the spacecraft simulators (similar to spacecraft-mission control communications) for use as measures of adjustment has not been accomplished.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BR5

11. SUGGESTED DEVELOPMENT APPROACH(ES) (OPTIONAL) See Item 8.

12. SPECIAL FACILITIES REQUIRED. Small group simulation facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. McDonnell Douglas 90-day simulation study.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Hazardous Complex Tasks

2. BRIEF DESCRIPTION. Identifying complex tasks that are hazardous because of man's physiological deconditioning in zero gravity or because he reverts to one-gravity habits under stress while in weightlessness and exerts excessive pressures that are inappropriate to zero gravity.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-3

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments not in space to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Experimenters must be familiar with past space activity performance and planned future systems and experiments. Subjects should be required to perform a battery of basic psychomotor tests and selected complex space activities. Then space-type deconditioning should be reproduced via bedrest-immersion facilities, and subjects again required to perform these tasks. Significant task performance changes will be identified, and their possible effect on the safety of the crew or hazard to the mission must be studied. Techniques for reducing hazards such as design changes or new design criteria, procedures, and training must be derived. Astronauts must accomplish these same activities prior to launch so a performance benchmark is available for comparison to zero-gravity conditioned performance.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Astronaut activities have been adequate for meeting operational mission requirements, but the effect of weightlessness for periods in excess of 2 weeks is not available. Both astronauts and cosmonauts have had to accomplish contingency mode re-entry activities because of automated system failures. Information on performance following extended flight is needed for design of both systems and equipment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important - some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BR3

11. SUGGESTED DEVELOPMENT APPROACH(ES). See item 7 and 8.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Training Problems and Equipment

2. BRIEF DESCRIPTION. Analytic Study of vehicle/mission tasks to identify potential inflight training problems and training equipments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-BR-4

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study; development; Experiments not in space to define present capabilities.

6. OBJECTIVES. Component; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Can be accomplished today for today's equipment and today's planned missions. Critical problems identified are expected to generalize to subsequent equipment and mission with minor modifications. An Earth analogy is required periodic refresher training for pilots, but frequency is not yet determined for astronauts. In-flight training is anticipated because flight lengths are extended in spacecraft. Just as pilots also need cross training when shifting to different aircraft, this and other similar requirements are anticipated products of analytic and simulation studies.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Procedures utilized in aircraft research programs may be applied to derive needed spacecraft/mission training needs and training equipment information.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This is a generalized STD requirement which could be described in explicit terms after survey of on-going study programs.

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Simulation facilities must be utilized following analytic study to further delineate task and training equipment requirements.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED.

None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two years for training problems; two years for training equipment.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

E

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Display/Control Computer Capabilities

2. BRIEF DESCRIPTION. Onboard computer hardware and software for controls and displays experiment.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-1

4. ITEM NO(S). Synopsis, Para. 3, 5

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGY GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Computer controlled display/control inputs to bulkhead and centrifuge consoles and recording of subject's performance plus reducing of data for transmission to principal investigators.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This capability exists in Earth laboratories, but not in a completely atuomated form. This capability does not exist aboard aircraft because analog computers and other weight penalties make the problem complex. Some direct telemetering of flight test performances is done to confirm satisfactory performances on fixed display and control panels.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-MM-1, STD MM2

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Work of Flight Development Laboratory, Wright Patterson AFB, Dayton, Ohio.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Display/Controls Experiment Apparatus

2. BRIEF DESCRIPTION. Experimental apparatus such as panels, consoles, replaceable displays and controls.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-1

4. ITEM NO(S). Synopsis, Para. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGY GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Multiman work station containing various controls and displays, capable of reconfiguration to permit different controls and displays to be mounted and to allow relocation of components on the panels; interconnection to a computer and data recordings, storing, retrieval, transmission facilities.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Apparatus exists in Earth laboratories. A limited amount of flight weight apparatus exists, but not in the variety and quantity needed for this experiment. Centrifuge does not exist as flight apparatus (GDA has been funded for development work) and this device is desirable for experimenting with displays and controls for operation under reentry stresses after extended periods in weightlessness.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-MM-1, STD MM1

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA has a centrifuge program. Both government and industrial labs have display/control research efforts.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Depends on variety and kind of apparatus stipulated -- $1 Million.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Dark Adaption Equipment and Techniques

2. BRIEF DESCRIPTION. Apparatus and procedures to better maintain dark adaption and recovery after exposure to glare.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-1

4. ITEM NO(S). Synopsis, Para. 1

TYPE OF STD EFFORT

5. ACTIVITIES. Experiment in space and not in space to define present capabilities.

6. OBJECTIVES OPERATIONS. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATION CAPABILITY. Expermenters need familiarity with missions and with experimental work in vision. Information needed for equipment design and mission planning includes the following: (1) time required for recovery from the glare of columnated sunlight to levels such as those provided by Earth shine at the lunar terminator or dividing line between night and day and those experienced when moving from sunlight to the shadow of the lunar module; (2) causes of degradation in time required for recovery such as shortage of oxygen, presence of toxics such as CO, fatigue, and advances in chronological age of subjects; (3) techniques to reduce time required for recovery such as breathing pure oxygen, using colored lens to reduce the effects of glare, and increased light levels in shadow.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Neil Armstrong said it was hard for him to see if he had good footing when in the shadow of the lunar module. He said "It takes a short while for my eyes to adapt to the lighting conditions." Both astronauts noted the reduction in visual acuity when in the shadow of the lunar module. On Apollo 8, Lovell, said "I can't see anything in Earth shine" at the terminator or dividing line between night and day. Visual aids to meet these problems have been developed for aircraft pilot use and should be studied and modified to meet needs in space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None known

11. SUGGESTED DEVELOPMENT APPROACH(ES). Described in Items 7 and 8.

12. SPECIAL FACILITIES REQUIRED. Oxygen mask/pressure compartment for controlled presentation of atmospheres of differing contents and pressures on Earth. Chamber with control overshadows for simulation of columnated light.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months for initial experiments, not in space.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for initial experiments, not in space.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Portable Metabolic Analyzer

2. BRIEF DESCRIPTION. Portable metabolic analyzer for space use.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-2

4. ITEM NO(S). 6, 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Required to develop a portable unit that is small enough to permit the crewman to perform his task without disturbing him. Theory is known--simply make it smaller and portable with a transmitter. Face mask picks up exhaled breath and transports a sample per breath to the analyzer. The analyzer takes a count of the oxygen consumed and of the CO_2 produced per breath. The transmitter produces a signal for each of the above, the signal is received and recorded by instrumentation outside the experiment task area. The recorder will read directly in metabolic rate of kcal consumed per minute on a breath-to-breath basis. The problem is one of packaging and miniaturization of existing equipment into an acceptable portable package.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory known but portable, flight-weight unit not available, also present response times are low and errors are too high.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Biomed and life support activity; Huntsville and Houston are developing portable units.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. On-body Accelerometer

2. BRIEF DESCRIPTION. On-body accelerometer for space use.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-2

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Must determine best way to instrument man to determine the acceleration loading on the various portions of his body when he makes impact with surfaces while utilizing locomotion and restraint devices. The means of defining or deriving the data is not of importance as long as the crewman is not interfered with during task performance and the results are consistent, repeatable, and measurable. Accelerometer detects acceleration and deceleration of that unit as placed upon the crewman's body. Detection and transmission to be constant from time of activation to time of deactivation. An approach is man-mounted accelerometer(s) plus transmitter that is hard-wired to a man-mounted multiple-channel transmitter. Individual accelerometer must be of a minimum size, possible for mounting on body points as the ankle(s), knee(s), hip(s), shoulder(s), elbow(s), wrist(s), and head.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theoretical understanding and technology exists, but integration and packaging must be accomplished.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BM7

11. SUGGESTED DEVELOPMENT APPROACH(ES). Open

12. SPECIAL FACILITIES REQUIRED. Earth Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Habitability Experiment Support Package

2. BRIEF DESCRIPTION. 24 hr/day time-lapse TV monitoring requirements and capabilities, computerized data analysis techniques, and prelaunch experimentation in simulated space research facility environment to establish parametric benchmark data.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-3

4. ITEM NO(S). Synopsis, Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Development; experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATION CAPABILITY. 24-hour time-lapse T. V. monitoring requirements: T. V. pickup cameras located through the habitable area that provide 100% coverage of all crew activities on a time-lapse basis; computerized data analysis capabilities; and prelaunch simulation in simulated spacecraft environment to establish parametric benchmark data.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Behavioral research in terrestrial labs has included the gathering of audio and video data, but through more liberal use of manpower, electrical, and computer capabilities than is feasible aboard the spacecraft. Generally the analysis have been accomplished following the experiments phase of research, much of it manually. The data have not been assembled for habitability measurements.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. BR5, BR6

11. SUGGESTED DEVELOPMENT APPROACH(ES). Utilize space cabin simulator crews during their life support system development programs.

12. SPECIAL FACILITIES REQUIRED. Ground laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Skylab A habitability work, 90 day/180 day OART Space Cabin Simulator Programs

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
TV Requirements, $250, 000
Computerized Data Analysis Capabilities, $250, 000
Simulation Studies, $500, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Emergency Reaction Time from Sleep

2. BRIEF DESCRIPTION. Identifying the emergency tasks that man may have to accomplish immediately after being awakened, the time required to awaken from light sleep and deep sleep and react to emergencies (Emergency Reaction Time).

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-4

4. ITEM NO(S). 48, Synopsis Para. 5.

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Identification of emergency tasks that may occur during sleeping watch hours and their characteristics (such as length of task, complexity of task, number of crewmen needed for task accomplishment, time available for repair before spacecraft life support capability becomes critical, and time available before system repairability becomes critical) and of ground-simulated preflight performance baselines.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present spacecrew procedures utilize Earth Mission Control as a continuous watch, thus permitting all the flight personnel to sleep simultaneously. However, the increased number of compartments and complexity/self-sufficiency requirements of future stations suggests that the flight crew assume responsibility for around-the-clock monitoring duties. This may or may not require that a crew member be awake at all times. Data is not available on the time required for man to awaken and accomplish emergency tasks.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-MM-4, STD MM8, 1-LS-11, STD LS16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Obtain data from space cabin simulator contracts and System Development Engineering Laboratories on operational and maintenance tasks known and anticipated. Obtain data regarding structure of planned future spacecraft and extravehicular hazards such as radiation and micrometeors. Then perform required ground tests, using a mockup spacecraft.

12. SPECIAL FACILITIES REQUIRED. Spacecraft mockup similar to spacecraft in which orbital experiment will be accomplished.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 for non-space experiments

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Equipment for Sleep Experiments

2. BRIEF DESCRIPTION. Experiment package of equipment development for supporting measurement of work/rest/sleep/ cycles in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-4

4. ITEM NO(S). Synopsis Para. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A need for sensors and alarms to awaken a man from bed in deep sleep and identify location and level of his danger so he knows whether to get the patch kit and plug the leak versus flee to a safe, air-tight compartment to don a pressure suit before solving the problem at hand. Need specification of appropriate locations and disposition or layout of pressure suits and repair kits, content of repair kits, location of pressure compartments. Equipment in MM7 and LS16 is needed to meet requirements of this experiment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Psychomotor Module of IMBLMS provides the hardware and software required to obtain measurements of simple and complex reaction time when awakened from light sleep to operate display/controls at console. Videotape camera and film constitute a measurement recording device used when awakening a man from deep sleep in sleep compartment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-MM-4, STD #MM8, 1-LS-11, STD LS-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Spacecraft simulator

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Performance Aids

2. BRIEF DESCRIPTION. Aids to man's performance at maintenance and repair, experiment operations, and data handling.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-MM-5

4. ITEM NO(S). Synopsis, Item 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities; Development

6. OBJECTIVES. System, Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.

   A. Development of universal, flexible task boards. Task boards are required for a variety of space experiments on evaluation of human capabilities and such task boards should be capable of being reconfigured in space so that they can serve their function over extended time periods while a given spacecraft is in orbit. An ideal situation would be to have one configuration of a task board capable of serving a number of different experiments over time periods as long as 10 years.

   B. Tool Selection Program. A ground-based space simulation effort is required to make preliminary evaluations of various powered and unpowered tools for a number of different space maintenance applications so that the tools selected for space experimentation are the best candidates.

C. Development of space version of a bilateral/master/slave electric remote manipulator. Ground devices are too cumbersome, too heavy, and require high power expenditures. A development effort to optimize a remote manipulator for a variety of space applications is necessary.

D. Development of optical aids for Earth surveys. For evaluation of man's capability to perform Earth survey operations, it is desirable that the best possible types of optical aids be furnished him. A development and flight test effort (using aircraft) is necessary.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Terrestial laboratories have some highly specific task boards, but no boards that would generalize across space tasks. Some space tools are available. Present remote manipulators are suitable only for ground use. No optical aids have been developed to date specifically for manned Earth survey missions.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Terrestrial space simulator laboratories, and aircraft used for parabolic flight testing.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 5 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multipurpose Fluid Physics Apparatus

2. BRIEF DESCRIPTION. Development of multipurpose fluid physics apparatus for both space physics and life support fluid behavior studies.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-1, -2; 1-LS-4, -5; (Important) 1-LS-3; 1-LS-7; 1-LS-9, -10

4. ITEM NO(S). 49, 51 (1-LS-1)

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Some apparatus required for the life support experiments is identical to that described for the Space Physics experiments. (See STD No's P-4 and P-5.) Additional requirements include a glass-tube condenser fitted for photometric observation of vapor condensation phenomena, and devices for measuring (1) Temperature, -100° to +250°F, ± 1%; (2) Pressure, 2 to 40 psia, ± 1%; (3) Flow Rate, 0.005 to 0.1 lb/sec, ± 3%; (4) dc power, 0 to 1500 w., ± 1% F.S.; (5) dc voltage, 0 to 110 v., ± 1% F.S.; (6) dc current, 0 to 50 a., ±1% F.S. A study is required to assess the feasibility of developing a common "fluid handling subsystem" for meeting requirements of both physics and life support.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. These apparatus are largely state-of-the-art, but will require qualification testing; g-level control and sensing, as described in STD Nos. P-5 and P-22, is also required.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. P-4, P-5 and P-22; research clusters 4-PC-2, -3, -9 and -10; STD Nos. LS-2, -4, -5, -8, -13

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None Known

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Zero-G Condenser

2. BRIEF DESCRIPTION. Atmospheric supply processes that utilize zero-g condensers require orbital tests for proof of the design principles.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-3; (Important) 1-LS-1; 1-LS-4; 1-LS-10

4. ITEM NO(S). 4, 50, 54 (1-LS-2)

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The theory of operation for atmospheric supply processes is well known. However, these systems have been operated for only limited lifetime during ground tests. Further technology development and operational capability is required for those atmospheric supply processes that utilize zero-g condensers.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory is well understood, but operational capability needs further development efforts for long duration systems in the space environment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -4, -13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Long duration system tests of candidate atmosphere supply processes installed in a space vehicle simulator.

12. SPECIAL FACILITIES REQUIRED. Tests to be performed under conditions that simulate in orbit operational constraints; space vehicle simulator required.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The STD could be integrated with overall environmental control and life support system tests such as the 90-day space vehicle simulator run performed by MDAC-W during 1970.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$600,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Catalyst Bed Poisons

2. BRIEF DESCRIPTION. Develop methods for monitoring and removing cabin atmosphere contaminants which poison catalyst beds.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-LS-3; 1-LS-7, -8; 1-LS-11, -12

4. ITEM NO(S). 6, 48, 50, Synopsis Item 5 (1-LS-3)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Various cabin contaminants must be evaluated as to their effects on Sabatier and Bosch catalyst beds, and appropriate monitoring and removal devices must be evaluated.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. It is presently known that certain spacecraft cabin atmosphere contaminants, such as freon, for example, have the capacity for poisoning Sabatier and Bosch catalyst beds. Level of sophistication of space hardware must be improved.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-8, -9

11. SUGGESTED DEVELOPMENT APPROACH(ES). Identify trace contaminants, along with their sources and effects on catalyst beds; develop monitoring and removal devices.

12. SPECIAL FACILITIES REQUIRED. Laboratory testing should be augmented by unmanned and manned tests in a space vehicle simulator.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Activity could be integrated into tests such as the 90-day test conducted at MDAC-W in a space vehicle simulator.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Negative Pressure Device

2. BRIEF DESCRIPTION. Design and verification of negative pressure devices to maintain Δp in zero g.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-LS-2, -3, -4

4. ITEM NO(S). 48, 50, Synopsis No. 5 (1-LS-4)

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Required are design evaluation and reliability improvement of negative pressure devices integrated with life support equipment in a zero-g environment. Effort should be oriented toward the integration of these devices into functional life support systems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Methods are known for maintaining a pre-established pressure differential across a zero-g condenser. These methods have been evaluated in a space vehicle simulator under one-g conditions. In general, devices function reliably in a laboratory environment, but reliability is greatly diminished when devices are integrated into a life support system.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -2, -3

11. SUGGESTED DEVELOPMENT APPROACH(ES). Integrate into a life support system and test in one-g.

12. SPECIAL FACILITIES REQUIRED. Laboratory required for build-up with subsequent evaluation in space simulators.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Systems could be evaluated in tests similar to the 90-day test in a space vehicle simulator.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $700,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Zero-G Phase Separator

2. BRIEF DESCRIPTION. Experiments and development effort required to define techniques for water-gas separation in zero-g and to refine design of catalytic filters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-4, -5; (Important) 1-LS-6; 1-LS-9

4. ITEM NO(S). 48, 51, Synopsis No. 5 (1-LS-4)

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Two-phase condensing of liquids from vapors in extended zero-g environment is required in order that the system operate successfully; water-gas separator must operate successfully in a zero-g environment for extended periods under varying flow conditions; catalytic filters are required to operate for extended durations under actual system operating conditions.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Two-phase flow condensation is well understood for Earth gravity environment; theoretical predictions are available for varying g, and short duration zero-g tests have been conducted; the theory regarding water-gas separators is understood, models have been built, and short duration zero-g systems operated; catalytic membrane filters understood, built and tested, need extended testing; such tests have been run on prototypes, but space-rated hardware must be developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -8, -9, -13; research cluster Nos. 4-PC-2, -3, -9, -10

11. SUGGESTED DEVELOPMENT APPROACH(ES). Two-phase flow condensation is a basic experiment that has already been written up, as has the basic experiment of water separation in zero-g.

12. SPECIAL FACILITIES REQUIRED. Breadboard in laboratory, then integrate into a functional life support system for support of manned tests in space vehicle simulators.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Activity could be integrated into tests such as the 90-day test conducted at MDAC-W in a space vehicle simulator.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Automatic Potability Measurement

2. BRIEF DESCRIPTION. Study of development of an automatic system which can measure and display potability parameters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-4; (Important) 1-LS-8; 1-LS-11, -12

4. ITEM NO(S). 40, 48, 50, 51, Synopsis No. 5 (1-LS-4)

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The ultimate criterion for the evaluation of water recovery techniques is whether they produce potable water. An automatic operational capability is required which can measure and display potability parameters. The most stringent requirement is the development of a rationale and technique for evaluating within a short time period whether microbial contaminants are present in water samples.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Potability parameters are now generally measured by standard non-automatic laboratory techniques. Although a capability does exist for the automatic measurement and display of some of them, no fully automated system now exists, especially regarding bacteriological contaminants which require culturing of samples for 48 hour periods.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD No. LS-15

11. SUGGESTED DEVELOPMENT APPROACH(ES). Buildup in laboratory; perform breadboard tests in space simulators.

12. SPECIAL FACILITIES REQUIRED. Standard laboratory environment to build and test system, followed by testing in space vehicle simulator and, ultimately in space.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The 90-day test in the space vehicle simulator at MDAC-W

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Five Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Low Flow Metering Device

2. BRIEF DESCRIPTION. Investigation of the development of low flow metering devices which can function in zero-g evaluations of water recovery systems.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-LS-4; 1-LS-9

4. ITEM NO(S). 48, 50, 54 (1-LS-4)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A capability must be developed so that reliable, low flow totalizers (metering devices) are available to function in zero-g evaluations of water recovery systems; these devices must be capable of measuring fluid flow (0 - 100 lbs/hr.) at an accuracy of ± 1%.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Currently available metering devices, designed for use in one-g environments, have proved to be unreliable and inaccurate when used as part of a water management system.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -14

11. SUGGESTED DEVELOPMENT APPROACH(ES). Buildup and preliminary testing in laboratory with subsequent integration into a water management system designed to support manned tests in a space vehicle simulator.

12. SPECIAL FACILITIES REQUIRED. Devices should be developed in the laboratory with development tests in a space vehicle simulator.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The STD activity could be integrated with tests in space vehicle simulators similar to the 90-day test conducted at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Separation of Effluent Gases from Electrolyte

2. BRIEF DESCRIPTION. Development and operation of capillary retention of liquid to prevent mixing with gases and liquids.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-5; 1-LS-7; (Important) 1-LS-12

4. ITEM NO(S). 48, 49, 50, and Synopsis No. 5 (1-LS-5)

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The theory and operation of water electrolysis systems is well known and these systems are widely used for the commercial production of hydrogen. Zero-g capability of the electrolysis cell is provided by containing the electrolyte and water feed in an asbestos matrix. Further technology development and operation capability is required for capillary retention of the liquid at the matrix interfaces to prevent mixing with gases and liquids and to prevent oxygen and hydrogen from mixing as they are produced.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory is well understood but equipment needs further development efforts for long duration systems in the space environment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -3, -5

11. SUGGESTED DEVELOPMENT APPROACH(ES). Long duration system tests of candidate water electrolyses systems installed in a space vehicle simulator.

12. SPECIAL FACILITIES REQUIRED. Tests to be performed under conditions that simulate in-orbit operational constraints; space vehicle simulator required.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This STD could be integrated with overall environmental control and life support system tests such as the 90-day space station simulator run performed by MDAC-WD during 1970.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2-1/2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Identification of Contaminants in Electrolyte Products

2. BRIEF DESCRIPTION. A study to identify trace contaminants in effluent gases from water electrolysis systems and development of flight type hardware.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-5; (Important) 1-LS-7, -8; 1-LS-11, -12

4. ITEM NO(S). 48, 49, 50, 51, Synopsis No. 5 (1-LS-5)

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A study effort is required in order to (1) identify sources and nature of effluent gas contaminants; (2) evaluate effluent gas purification techniques; (3) determine type of contaminant analyzers and the frequency of analysis; (4) evaluate analysis requirements during electrolysis on and off design performance. A development effort is required to produce flight type hardware.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The effluent gases from water electrolysis units may be contaminated by cross diffusion of H_2 and O_2, products from contaminated water (for example, NO, from NH_3 contaminated water). N_2 from the system pressure control, and contaminants from unit bonding agents; all of the potential sources of contaminants have yet to be identified and their products analyzed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-3, -5

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extract gas sample from prototype electrolysis units and conduct laboratory analysis on sample; evaluate during on and off design performance.

12. SPECIAL FACILITIES REQUIRED. Effort may be expended in a laboratory by breadboarding appropriate components with subsequent analyses in a space vehicle simulator.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Tests in space vehicle simulators similiar to the 90-day test conducted at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Evaluation of Hydrogenomonas Eutropha Reaction Chamber

2. BRIEF DESCRIPTION. Study of hydrogenomonas mixing reaction chamber in zero-g.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-6; (Important) 1-LS-7; 1-LS-11

4. ITEM NO(S). 2, 49, 50, Synopsis No. 5 (1-LS-6)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The capabilities and limitations of hydrogenomonas eutropha in the production of protein from substrates such as H_2, CO_2, urea, O_2, H_2O and metabolic wastes must be determined in a weightless environment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The capability of hydrogenomonas eutropha to produce protein from waste and other substrates has been demonstrated in the laboratory; the effort is to eventually utilize these proteins as edible food for prolonged space missions.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-11, -14

11. SUGGESTED DEVELOPMENT APPROACH(ES). Evaluate bacterial function in a mixing reaction chamber in a laboratory environment, subsequently in space.

12. SPECIAL FACILITIES REQUIRED. Microbiology laboratory required; system should subsequently be evaluated in a space vehicle simulator prior to tests in zero-g.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Programs such as the 90-day test in the space vehicle simulator at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $600,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Integration of Hydrogenomonas Eutropha System Components

2. BRIEF DESCRIPTION. Study of the integration of mixing chamber, water electrolysis unit, and incinerator.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-6; (Important) 1-LS-7; 1-LS-9

4. ITEM NO(S). 2, 49, 50, Synopsis No. 5 (1-LS-6)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An integrated system consisting of an incinerator to treat feces, an electrolysis unit to produce H_2 and O_2 from water, and a bacterial chamber which converts wastes to protein must be integrated into a functional system; each unit should be evaluated on an individual, modular basis before being integrated into the system.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The capacity of hydrogenomonas eutropha to convert CO_2 via H_2, O_2, H_2O and metabolic wastes into protein has been demonstrated in the laboratory; the function of incinerators in processing feces and the function of water electrolysis units are known; the processing of feces for the bacteria and the bacterial process must be developed into an integrated space-rated system.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-10, -14

11. SUGGESTED DEVELOPMENT APPROACH(ES). Develop breadboard H. E. conversion system; utilize as part of life support system in a simulator; then develop space hardware.

12. SPECIAL FACILITIES REQUIRED. Modules should be laboratory tested, integrated for space vehicle simulator tests, and subsequently tested in space.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. System (see 11) could be evaluated in simulations such as the 90-day space vehicle simulator test at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Development of CO_2 Removal Methods

2. BRIEF DESCRIPTION. Investigation of hardware development for orbital tests of carbon dioxide removal methods.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-3; 1-LS-7; (Important) 1-LS-11

4. ITEM NO(S). 49, 51, Synopsis No. 5 (1-LS-7)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Theory, System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Hardware, components, and systems must be developed to permit orbital evaluation of these four carbon dioxide concentration techniques: (1) adsorption on Zeolite beds; (2) adsorption by solid amine; (3) adsorption by carbonation calls; (4) electrodialysis.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory of operation of atmospheric purification methods is well understood and ground level hardware has been evaluated in various environmental control and life support systems tests.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD No. LS-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Breadboard equipment in the laboratory; evaluate long duration function; establish component compatibility; and proof of design prior to integration into a life support system for one-g development test.

12. SPECIAL FACILITIES REQUIRED. Buildup in laboratory, test in space station simulator.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Programs such as the 90-day test conducted in the space vehicle simulator at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $800, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

C2

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Boiling and Condensing Steam

2. BRIEF DESCRIPTION. Study of the boiling and condensing of steam in zero-g environment for the solid amine system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-1; (Important) 1-LS-3; 1-LS-7

4. ITEM NO(S). 48, 51, Synopsis No. 5 (1-LS-7)

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The theory and operation of atmospheric purification methods is well known; further technology development and operation capability is required for the solid amine system for boiling and condensing steam in the zero-g environment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory is well understood, but equipment needs further development efforts for proof of the design principles.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-1, -2, -4, -5

11. SUGGESTED DEVELOPMENT APPROACH(ES). Long duration system tests of candidate atmospheric purification methods installed in a space vehicle simulator as part of a development test effort to evaluate component compatibility and proof of design principles.

12. SPECIAL FACILITIES REQUIRED. Tests to be performed under conditions that simulate in-orbit operational constraints; space vehicle simulator required.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Overall environmental control and life support system tests such as the 90-day space vehicle simulator run performed by MDAC-W in 1970.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $675,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Waste Management Systems

2. BRIEF DESCRIPTION. Development of hardware for orbital tests of waste management system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-9; (Important) 1-LS-6

4. ITEM NO(S). 49, 50, Synopsis No. 5 (1-LS-9)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Hardware, components, and systems must be developed to permit orbital evaluation of various waste management systems; system concepts extend to (1) Air entrainment with fecal slurry formation; (2) Air entrainment with vacuum drying; (3) Manual bagging and storage using chemical treatment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory of operation of waste management systems is well understood; interrelationships with waste sampling for metabolism studies for the one-g environment are also well understood; hardware does not exist for use in space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-7, -10, -11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Begin with study, effort to establish hardware requirements; follow up with testing in one-g to evaluate component compatibility and proof of design principles.

12. SPECIAL FACILITIES REQUIRED. Develop in laboratory; test in space vehicle simulator prior to evaluation in zero-g.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Programs such as the 90-day test conducted by MDAC-W in a space vehicle simulator.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $800,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Microbial Detection and Suppression

2. BRIEF DESCRIPTION. Study of development of a system for microbial detection and suppression.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-LS-11; (Important) 1-LS-3; 1-LS-7, -8; 1-LS-12

4. ITEM NO(S). 3, 49, Synopsis No. 5 (1-LS-11)

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Realization of a microbiological detection and suppression system will require the capability of qualitative and quantitative analysis and rapid response. Design of such a system must be based on a thorough understanding of the characteristics of candidate organisms at the subcellular or molecular level coupled with knowledge of the effects of the spacecraft environment on them. Accomplishment of the above will require significant scientific breakthroughs at the genetic and molecular levels.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The present level of microbial detection is Earth oriented and time consuming. It is generally based on empirical knowledge derived from observations of such characteristics as growth, colony formation, gas production, and staining. No store of empirical information exists as to development of these characteristics in space, nor as to the interpretation of any characteristics observed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD No. LS-6

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Microbiological laboratory; space vehicle simulator

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS Development Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 5 to 10 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Systems Integration of Sensors

2. BRIEF DESCRIPTION. Incorporation of monitoring and protective equipment into an integrated system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-LS-3; 1-LS-7, -8; 1-LS-11, -12

4. ITEM NO(S). 3, 50, 51, Synopsis No. 5 (1-LS-11)

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An integration effort is required wherein sensors and monitoring devices are incorporated into a system which maximizes the utility of each component. Such a system would employ for instance, a mass spectrometer not only for fire and thermal protection (combination product sensor) but also as an atmosphere trace contaminant monitor.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The understanding and technology required to monitor and provide corrective measures for all but one of the identified functional areas exist and a development effort will result in incorporation into a reliable flight type system. Current technology, however, cannot provide required microbial detection and control. (This item is the subject of STD LS-15.)

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD Nos. LS-3, -12

11. SUGGESTED DEVELOPMENT APPROACH(ES). Long duration tests of candidate components installed in a space station simulator could establish component compatibility and proof of design principles.

12. SPECIAL FACILITIES REQUIRED. Console should be breadboarded in a laboratory and subsequently evaluated in a space station simulator utilizing appropriate atmospheres and pressures.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Programs such as the 90-day test conducted in a space vehicle simulator at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Waste Management System Concepts

2. BRIEF DESCRIPTION. Study effort to evaluate waste management concepts relative to aerobic and anaerobic biodegradation, gamma irradiation, and wet oxidation.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-LS-9

4. ITEM NO(S). 54, Synopsis No. 5 (1-LS-9)

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory; Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A study effort is required to establish a candidate waste management technique based on efficiency of function in zero-g and compatibility with other onboard systems (especially with life support systems).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The principles of waste management relative to aerobic and anaerobic biodegradation, gamma irradation, and wet oxidation are well understood and a considerable amount of experience has been gained in the one-g condition. Hardware for biodegradation, dry incineration and wet oxidation is now in the development stage.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 1-LS-1, -2, -4

11. SUGGESTED DEVELOPMENT APPROACH(ES). Evaluate concepts from such aspects as reliability, compatibility with other systems, power requirements, and maintainability prior to selection of candidate techniques.

12. SPECIAL FACILITIES REQUIRED. No Special Facilities

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Data for this study could be derived from programs such as the 90-day test conducted in the space vehicle simulator at MDAC-W.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

STD ITEM
NO. EE-1

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Biowaste Electrical Propulsion

2. BRIEF DESCRIPTION. Integrated biowaste electrical propulsion reaction control system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-EE-3-3

4. ITEM NO. Synopsis, Paragraph 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments not in space to define present capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An integrated system must be designed which includes a pump, accumulator, heater, gas analyzer, logic and control system, recorder display, resistojet thrustors, plumbing and valves, an alternate gas source reserve, and pressure, temperature, voltage, and power sensors (see Item 51). This system will interface and be integrated with the EC/LS Sabatier system and the controls of the nominal reaction control system. The problems involved in handling, sampling, analyzing, and efficiently using a diverse range of propellants must be analyzed through a systems study. A versatile system must be built to space test (as per research cluster) the candidate configurations derived from the study, including accessible and exchangeable components.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Resistojets are currently being developed and tested to run on specific biowaste mixtures. Integrated tests with the life support system for ground and space are being defined. No system exists which is designed to operate with a diverse

range of propellant chemical compositions. On-line analysis of propellants (CH_4, CO_2, H_2, H_2O and others) in a zero gravity environment poses a problem. Data from this analysis is required for control algorithms, which have yet to be derived, which will optimize the system.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EE-2, EE-3

11. SUGGESTED DEVELOPMENT APPROACH(ES). System study to identify problem areas. Modify, develop, and ground test components. Simulate operations on ground. Integrate components into system and ground test.

12. SPECIAL FACILITIES REQUIRED. The guidance and control system of the space facility must be designed to use both the nominal system and the less powerful biowaste control system.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MSFC-DRL-160, Contract NAS8-25140, Space Station

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. System Study 18 Months; System Development 18 Months; concurrent with development of ground experiments and simulation, 12 Months; total 36 Months.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

STD ITEM
NO. EE-2

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Biowaste Resistojets

2. BRIEF DESCRIPTION. Biowaste resistojets capable of withstanding a wide range of propellant compositions.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-EE-3-3

4. ITEM NO. 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments Not in Space to Define Present Capabilities

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Requirement for the development of biowaste thrusters made of materials that can survive elevated temperature in the heater and nozzle for long periods of time while exposed to a diverse range of propellant chemical compositions. Heater temperature to 3000°F, propellant flow rate of approximately 10^{-4} lb/sec. Gases will include CH_4, CO_2, H_2, and H_2O; further analysis is required to derive specifications.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Resistojets have been operated on a variety of propellants. They are currently being developed and tested to run on specific biowaste mixtures. No data is available for a diverse range of gases. Problems are anticipated for some hot gases such as methane.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EE-1, EE-3

11. SUGGESTED DEVELOPMENT APPROACH(ES). Such items as expected gas mix and temperatures should be derived from EE-1. This data can be used for selection of materials. Ground tests are to be made as required. Component development will follow after trade studies are made. Perhaps several candidate components will be fabricated and interchanged during space experiments.

12. SPECIAL FACILITIES REQUIRED. The components developed will be tested as part of the research cluster objectives, i.e., integrated with the biowaste electric propulsion system on a space facility. Observations, maintenance, and replacement by EVA may be required, but this won't be known until the studies for EE-1 and EE-3 are completed.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MSFC-DRL-160, Contract NAS8-25140, Space Station

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Studies 9 Months; Concurrent Experiments 3 Months; Development 12 Months; Total 21 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Biowaste Resistojet EVA

2. BRIEF DESCRIPTION. Biowaste resistojet EVA for observation, maintenance, repair, and replacement of thrusters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 1-EE-3-3

4. ITEM NO. 94

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments Not in Space to Define Present Capabilities

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This STD is dependent upon the studies and developments resulting from STD EE-1 and STD EE-3. If these STD's call for the maintenance, repair, and replacement of the thrusters for the Biowaste Electrical Propulsion Reaction Control System then studies and non-space experiments will be called for to determine what EVA is required for these operations and specific activities and tools must be defined. At a minimum, required EVA operations must be tried in simulated trials on the ground.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Specific complex EVA tasks have been simulated, however much is still to be learned by ground simulation. EVA activities in space are limited in number and complexity. (See also Appendix H.)

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EE-1, EE-2; see also research cluster 1-OE-2 Synopsis, OE-1, and Appendix H.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Design and development of resistojet hardware must be accomplished with knowledge of the expected state-of-the-art of EVA capabilities. EVA studies and experiments should be integrated into larger EVA study and experiment programs.

12. SPECIAL FACILITIES REQUIRED. EVA support, spacesuit.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MSFC-DRL-160, Contract NAS8-25140, Space Station

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Study (as part of a larger EVA study program) 6 Months; experiments (integrated with other EVA experiments) 6 Months; total (contingent upon requirement) up to 12 Months.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Study (increment to larger program) $50, 000; experiments (increment to larger program) $150, 000; total (contingent upon requirement) up to $200, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Laser Ranging System

2. BRIEF DESCRIPTION. Onboard laser ranging system

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-EE-4-1; (Important) 1-EE-4-2, -4-4

4. ITEM NO. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The experiment calls for evaluation of the capabilities of a high powered laser ranging device to provide precise altitudes or range positions which will be part of an autonomous integrated navigation system. A study is required to define the system which is to be used including the hardware and software requirements. Trade studies should be made to determine the selection or required development of the laser(s) to be used. The development of the system is then required to incorporate the laser and other planned or existing navigation, communication, and data management equipment of the space facility.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Basic theory for such a system is established. Experimental designs of required high-powered lasers have been built. However no such operational system has been built and specific problems to be solved will be revealed by a system study (such as system compatibility, applicability to the problem of continuous autonomous navigation, resolution, noise, and target acquisition).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EE-6 for Study

11. SUGGESTED DEVELOPMENT APPROACH(ES). See Item 7

12. SPECIAL FACILITIES REQUIRED. Space platform; systems which can navigate and determine orbit parameters independent of laser(s); land-based corner reflectors; accurate survey data of selected landmarks.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A survey is required of existing and advanced concept studies for lasers and their applications. These include military developments which may be classified, and also the following (MDAC): (1) IRAD LID-E39-70-E35 "Onboard Navigation"; (2) IRAD LID-W35-69-31 "Onboard Navigation"; (3) IRAD LID-W35-69-27 "Electro-Optic Techniques"; (4) IRAD LID-A27-68-210 "Optical Tracking and Communication System"; (5) IRAD LID-4-2E "Mission Analysis Tools"; (6) IRAD LID-4-38 "Orbital Navigation Performance Analysis"; (7) IRAD LID-W32-69-E18 "Communications and Signal Processing".

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months for System Study; 18 Months for System Development; Total 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million for System Study; $2 Million for System Development; Total $3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Landmark Tracker System

2. BRIEF DESCRIPTION. Landmark tracker system study and development.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-EE-4-3; (Important) 1-EE-4-4

4. ITEM NO. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An integrated system is required using such items as electro-optical tracker, star trackers, computer and accelerometers. As the vehicle overflies the landmark, angle data from the landmark tracker and the inertial attitude reference data are used simultaneously in a computerized Kalman filter. This updates and improves previous estimates of the vehicle orbit parameters and the coordinates of the landmarks being tracked.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Known Landmark Trackers (KLT) flown on Apollo mission with little success. Unknown Landmark Tracker (ULT) has been test-flown but development highly classified. The information that is available indicates that advances in the development of optional filtering techniques are required. A system study must be pursued to determine advanced hardware requirements. (This STD assumes classified developments are either incomplete, unavailable, or unsuccessful.)

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Survey of existing systems, incorporate classified studies and developments when possible. Systems study, hardware development if necessary and software development, hardware acquisition, system integration, and simulation.

12. SPECIAL FACILITIES REQUIRED. Space platform with guidance and control, navigation and data management systems.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. ULTRA AFAL-TR-69-21; MDAC-IRAD LID-E39-70-35 "Onboard Navigation"; -M37-69-201 "Space Positioning Study"; -4-2E "Mission Analysis Tools"; -4-38 "Orbital Navigation Performance Analysis"; and -M37-69-201 "Space Positioning Study".

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Month for Survey; 11 Months for System Study; 6 to 12 Months for System Development; Total 18 to 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $3 Million; may be less if partial system available and applicable.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Long Range Optical Communications

2. BRIEF DESCRIPTION. Long-range optical communications system study and development.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-EE-5; (Important) 1-EE-4-2

4. ITEM NOS. 5 and Synopsis, Paragraph 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A deep space vehicle (DSV) such as a Mars or Venus orbiter equipped with a laser communication transmitter is required. The manned Earth orbiting station is to be equipped with a corresponding optical receiver. The DSV will have a CO_2 laser transmitter, Pockels cell modulator, gimballed refracting telescope for antenna, power supplies, message storage, precise timing synchronizer, and telescope pointing controls. The orbiting station will include a telescope, pointing controls, message storage and analysis, power supplies, and precise timing synchronizer. Bit rates of 100 kilobits/sec will be modulated on the laser beam; pointing accuracies of 0.25° and rate stabilities of 0.003°/sec are nominal but subject to change with analysis. A systems study should be made to define the requirements for developing an operational system. Problem areas anticipated include modulation of laser beam for deep space communication, stabilization and pointing accuracies of transmitter and receiver, and coordination of transmitter and receiver for acquisition. A development program for the system will follow the study.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Communication modulation of laser beams has been accomplished for relatively short distances. Theory and proposals have been advanced for deep space communication but a specific system has never been completely analyzed and a deep space laser communication system has never been built.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEM WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EE-4 for Study

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of existing studies with specific trade studies and design incorporating the system elements which are to be used. Development program should proceed as prescribed by system study.

12. SPECIAL FACILITIES REQUIRED. Manned orbiting platform, deep space probe, and system elements as outlined in Item 7.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. "Pulsed Visable Laser Communication Experiment for ATS-G", Report MDC E0031, 1/12/69; MDAC-ED Study Report HO 36, 3/14/69; MDAC IRAD LID - E35-70-E19 "High Data Rate Communications and Technology", - W35-69-E19 "High Data Rate Communications and Technology", and - A27-68-209 "Optical Communication Analysis".

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months for System Study; 18 Months for System Development; Total 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. System Study $3 Million; System Development $7 Million; Total $10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Assembly Techniques Study

2. BRIEF DESCRIPTION. Assembly techniques study including tools, locomotion, and restraint.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 1-OE-3; (Important) 1-OE-1-1, -1-2, -4; 1-BR-1-1, -1-3, -1-4, -3, -4; 1-MM-2

4. ITEM NOS. Synopsis, Item 5; 1-OE-3, Item 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments Not in Space to Define Present Capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING TECHNOLOGY OR OPERATIONAL CAPABILITY. The deployment of a 300-foot diameter antenna would require a support boom approximately 160 feet long. This structure would be designed as a one, two or three piece beam utilizing lightweight material in its construction. Deployment and assembly will require two astronauts and approximately 8 hours EVA time. (1-OE-3, Item 6). A comprehensive study is required to define the operations required, the method of assembly, the type of tools that must be developed, the methods of locomotion for the astronauts and deployment for the structure members, and the location and design of restraints. Candidate methods and equipment should be tried under simulated conditions on the ground.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. No EVA activities of such complexity have ever been attempted in space. No generalized or standardized EVA theory, methods or equipment exist. The state-of-the-art of EVA is described in Appendix H.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Appendix H

11. SUGGESTED DEVELOPMENT APPROACH(ES). This study solves a specific assembly problem. A universal study concerned with assembly, resupply, maintenance, repair, and other operations involving EVA would include the problems of this study and would have far reaching value.

12. SPECIAL FACILITIES REQUIRED. EVA simulation facilities

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Skylab A

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months for Operations Study; 6 Months for Concurrent Simulation Experiments; Total 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Operations Study \$250,000; Simulation Experiments \$250,000; Total \$500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Amino Acid Analyzer

2. BRIEF DESCRIPTION. The development of a space rated amino acid analyzer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space to define present capabilities; development.

6. OBJECTIVES. Component; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The amino acid analyzer must hydrolyze a protein sample, separate the amino acids by column chromotography or other acceptable method, react the amino acids with suitable segments for identification and record the amount of each amino acid. The apparatus should work automatically after the introduction of the sample and initiation of the cycle.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A presently existing model (Beckman Model 120C) utilizes ion-exchange chromotography for amino acid separation and the ninhydrin color reaction for analysis of concentration with automatic recording. The analyzer provides traces representing effluent absorption at 570 mμ and 440 mμ. Samples as small as 0.02 micromoles may be analyzed. The 20 amino acids found in proteins can be charted in 2 hours and the 50 amino acids and related compound found in physiological fluids in 11 hours. It is questionable whether the techniques employed by the instrument can be used in zero g.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Modification of present techniques for zero g use.

12. SPECIAL FACILITIES REQUIRED. Ground-based and orbiting laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 year for space experimentation, 3 years for development if required.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for space experimentation, $2 Million for development.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. -180°C Freezer

2. BRIEF DESCRIPTION. The development of a freezer to maintain tissues at -180°C without using a consumable product such as liquid nitrogen.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Refrigeration for certain biological samples is required at temperatures of -320°F (-196°C). This requirement should be met without the use of consumable products. Storage requirements are estimated as a minimum of 10.5 liters.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present refrigerators obtaining this degree of cooling use liquid nitrogen at a consumption rate of 0.34 - 0.36 liters per day. Model LR-10A-6 produced by the Linde Division of The Union Carbide Corp. has a capacity of 10.4 liters, a height of 21 inches, an outside diameter of 10 1/4 in. Its weight is 37 lb when full; 14 lb when empty.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Joule-Thompson or Stirling cycle applications.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 to $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Animal Cages

2. BRIEF DESCRIPTION. The development of specialized zero g cages for primates and animals which have provision for environmental control, feed and water, waste removal, and cleaning.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 2-VB-1, -2, -3; (Important) 2-IN-1, -2, -3

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Because the measurements program is to observe zero g effects, the cages must provide creature comforts similar to best laboratory conditions on earth. The 3-D space in the cages must be able to absorb animal wastes. The atmosphere must be maintained at the desirable temperature, composition (R.H., O_2, N_2, and CO_2), and pressure. Means of locomotion must be provided. Food and water must be made available. If daily mass determinations are to be useful, the animals must be kept clean and dry. In addition, some arrangement must be made to obtain urine samples for preservation until stress analysis determination is made.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. In normal earth atmosphere, all the above requirements are relatively simple. The problem is to understand the available natural conveniences well enough to define them as design requirements for zero g environment. Information from Biosattelite III primate module would be applicable to this problem.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-4

11. SUGGESTED DEVELOPMENT APPROACH(ES) Provide 3-D, absorbent material in cages that can be reactivated. Cages should be modular for spray-washing. Provide for atmospheric flow to facilitate O_2/CO_2 measurements.

12. SPECIAL FACILITIES REQUIRED. Design to facilitate biocentrifuge requirements for cage removal and replacement without stopping biocentrifuge, and for immobilized animals with implanted instrumentation.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Biotechnology Laboratory Study (Skylab II).

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $75,000 to $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Biocentrifuge

2. BRIEF DESCRIPTION. The development of a biocentrifuge for animal experiments for full period of orbital flight.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. In order to separate experimentally the effects of weightlessness from other phenomena such as isolation from cyclical cues, in-space controls for certain experiments should be run at 1 g. This gravity level can be attained on onboard biocentrifuge. The centrifuge must be capable of prolonged operation without shutdown (at least 90 days), the biological subjects must exist in a 14.7 psia, N_2-O_2 atmosphere, and individual cage or specimen removal must be accomplished without centrifuge shutdown or disturbance of the other cages. The centrifuge must be capable of accommodating numerous, diverse specimens, simultaneously.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. There are numerous centrifuges in ground based laboratories. Only a very few, however, have the capability of prolonged operation and none (to the author's knowledge) has the capability of individual cage removal. No onboard

centrifuges have been developed for spacecraft. General Dynamics, Convair Division has performed a feasibility and design study for an onboard man centrifuge which has some characteristics similar to the biocentrifuge.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-3

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The human centrifuge program has some common features.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 5 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10 to $15 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Surgical Procedures

2. BRIEF DESCRIPTION. A study of zero g surgical procedures.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Removal and preservation of organs and embryos from animals that have experienced 30 to 60 days of weightlessness is required. For such dissection and subsequent evaluations, surgical procedures and equipment to prevent fluids and gases from escaping into the atmosphere, or to prevent contamination of the animals is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present surgical techniques are gravity dependent - particularly in fluid and equipment handling.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Vacuum hoods or glove-box facilities may be advantageous.

12. SPECIAL FACILITIES REQUIRED. Ground and space laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Autoclave

2. BRIEF DESCRIPTION. The development of a zero g autoclave.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 2-P/T-1, -2, -3; (Important) 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An autoclave capable of generating a steam pressure of 15 psig at 121°C for a 15 to 30 minute sterilizing cycle. It will be used for equipment sterilization or culture sterilization prior to dispoal. The various cycles should be automatic for ease of use by spacecraft crewmen. The capacity of the autoclave should be about 1.5 cu ft.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Autoclaves exist in ground-based laboratories. Their operation includes some gravity dependent aspects such as condensation and drainage of the steam after sterilization. These processes must be modified for space use.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS development.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Incubator

2. BRIEF DESCRIPTION. The development of zero g incubator.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-P/T-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An incubator will be required with an operating temperature of 37°C ± 1°C and CO_2 concentrations selectable from 0 to 20 percent. The capacity should be 7 or 8 cu ft.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Most ground-based versions utilize gravity dependent convective heating. Forced convection or radiant heating must be used as a substitute.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The IMBLMS development program includes an incubator without the CO_2 capability.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Tissue Processor

2. BRIEF DESCRIPTION. The development of a space rated tissue processor and staining system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Automatic processing and staining of tissues is a requirement for the space biology laboratory. The system (equipment) should provide for automatic dehydration, fixation, and infiltration of animal and vegetable tissues on a selectable program - usually requiring a 24 hour cycle. The tissues will then be sectioned on a microtone and returned to the system for staining. The staining program should contain the flexibility for various staining procedures. The programs should be selectable and applicable to a 1 hour staining cycle.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Van Waters and Rogers, Model 48657-106 Dual Unit Tissuematon provides the required operations for terrestrial laboratories. It is 26 inches in diameter and 23 inches high; it operates on 60 Hz current and has a maximum power consumption of 260 watts. Its weight is 155 pounds Many of its operations, particularly those involved with fluid handling, are highly gravity dependent.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Use of a single, sealed tissue chamber with a positive pressure feed and evacuation system for liquid injection. System could be mounted on slow rotation centrifuge to provide sufficient centrifugal force to prevent free-floating of liquid after injection.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Activity Platform

2. BRIEF DESCRIPTION. The study and development of a space rated activity platform.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An apparatus is required to measure animal activity by sensing vibrations produced by animal movements, against an enclosure. Enclosed animals either must be held in contact with platform or detectors also must be installed in walls and ceiling.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present operation is based on ability of animal to maintain contact with sensor platform, thereby, transmitting all kinetic energy directly to sensor. Animals contact with platform is gravity dependent.

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PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-10, B-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Possible use of low clearance grid to ensure animal-platform contact.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Visual Cliff

2. BRIEF DESCRIPTION. A study of a space rated visual cliff.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A device for investigating depth perception in animals is required for space studies. The device should elicit an observable response from the animal to visual fields of contrasting depths. The device should utilize conditioned or inate responses as the indicator of depth perception.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The device used presently in such studies is the "visual cliff" which consists of a sheet of glass supported 2 feet above the floor of a box. Under one-half of the glass, a pattern is flush with the underside of the glass. Under the other half, the pattern is on the floor of the box. A tendency in animals to go to the "flush" side is considered indicative of depth perception. A new technique presumably is required for zero g.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-9, B-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Animal Maze

2. BRIEF DESCRIPTION. The study and development of a space rated animal maze.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A device is required for the systematic, analytic study of learning in animals in space. The data derived should be directly applicable to learning, should be quantifiable, and should allow program changes to permit degrees of task difficulty and permit analysis of involved mechanisms. A technique should be developed which will not only permit testing in space but which is also applicable to ground based controls.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An animal maze is the current device used for such studies. All known mazes are essentially two dimensional and are highly gravity dependent.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-9, B-10

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based and space laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year (for study). 2 Years (for development and development testing).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000 (for study). $500,000 (for development and development testing).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Bunsen Burner Substitute

2. BRIEF DESCRIPTION. A study for a bunsen burner substitute for zero g experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-P/T-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Component; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Operational capability required is rapid sterilization of inoculating needles for microorganism transfer. High temperature (1,300°C) is required for sterilization.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Ground-based approach is a simple bunsen burner using natural gas.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). An alternative may be prepackaged, presterilized equipment that can be resterilized and repackaged.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS development program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Liquid Handling

2. BRIEF DESCRIPTION. Liquid handling in weightlessness for space biology experimentation.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Liquid handling is required in a large number of space biology experiments. The handling operations include: (1) the simple transfer of a liquid from one container to another, (2) the measurement of the total amount of a liquid and the extraction and transfer of a precisely measured aliquot, (3) the combination (complete mixing) of a liquid with a dry or liquid reagent, (4) the placement of liquid drops on a slide for microscopic examination, and (5) the accurate, bubble-free filling of cuvettes and other containers associated with analytical instrumentation. (All of the indicated operations will encounter difficulties under zero g.)

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Almost all liquid handling techniques in terrestrial laboratories are gravity dependent utilizing pouring or dropping techniques with open containers; containers are calibrated on the basis of liquids settling on the bottom and bubbles rising to the surface. The techniques and equipment must be significantly modified for spacecraft use.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. B-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). The possibility of utilizing the manned onboard centrifuge for certain operations.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory and orbiting laboratory.

13. KNOWN ONGOING ACTIVITIES (STUDIES, EXPERIMENT PROGRAMS, DEVELOPMENT PROGRAMS, ETC.) WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Probably some techniques being investigated in conjunction with IMBLMS development. The design of the various animal modules and holding facilities will benefit from this STD.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 to 3 years for integrated study and experimentation.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Microbial I. D.

2. BRIEF DESCRIPTION. The development of a rapid, automated microbial identification system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-P/T-1, -2, -3

4. ITEM NO(S). 5, 48

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Operationally should be able to rapidly identify organisms by utilizing pyrolysis and gas chromatography, or spot scanning device of microbial colonies with computer readout of specific identifying characteristics.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Development of both these methods is under way (see Item 13), however, there are many technical problems to be worked out before either are operational or reliable.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Items are under development.

12. SPECIAL FACILITIES REQUIRED. Bacteriology laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS, Microbiological Ecology Measurement System, and Microbial Load Monitor.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 5 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Homogenizer

2. BRIEF DESCRIPTION. The development of a zero g homogenizer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The ideal homogenizer would ingest the specimen within its volumetric range and provide complete breakdown of all cellular material by means of a recycling flow through the homogenizer unit which would "flow-full" on a small percentage of the specimen. Discharge of the specimen and subsequent flushing and cleaning must be provided.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Existing homogenizers presume normal gravity for liquid containment and feed to the rotor, as well as presuming that specimens can be poured in and drained out. Cleaning presumes normal dishwashing techniques.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Dialysis Equipment

2. BRIEF DESCRIPTION. The development of dialysis equipment for use in zero g experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A requirement exists in space biology experimentation for the concentration of biocolloids in body fluids following continuous flow electrophoresis and for adjusting the electrolytic concentration of biological solutions preparatory to free electrophoresis. Presently these processes are carried out by dialysis either through osmotic transfer or by electrodialysis. The equipment should be capable of handling 10 to 15 samples simultaneously.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The process of membrane dialysis should not be adversely affected by weightlessness. However, the current devices -- Scientific Products Multiple Dialyzer, Model D1600-1 or - Electrodialysis Cell D1625 -- utilize extensive fluid handling operations in their function. The devices will probably require extensive modification for space use.

E

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Blood Cell Counter

2. BRIEF DESCRIPTION. The development of a space rated blood cell counter.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The requirement exists for making rapid, accurate determinations of red blood cells, white blood cells, platelets, hematocrits and hemoglobin concentration. The determinations should be automatic in order to reduce crew time. Red blood cells should be counted with an accuracy of about ± 1 percent, white blood cells ± 3 percent, platelets ± 3 percent, and hemoglobin and hematocrit ± 1 percent. About 30 samples should be able to be counted per hour.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An existing device -- the Coulter Counter Model F -- equipped with standard accessories will meet the above requirements. It measures 13 1/2 inches by 19 inches by 19 1/2 inches plus accessories. Many of its operating characteristics appear to be gravity dependent however and some modification will be required for space use.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Fluid Electrolyte Analyzer

2. BRIEF DESCRIPTION. The development of a zero g fluid electrolyte analyzer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Apparatus must be developed for the analysis of electrolyte (Na, K, Ca, Mg, etc.) concentrations in body fluids onboard the spacecraft. The method employed must be compatible with weightless operations and the spacecraft environment.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present systems operate by atomizing the solution in a flame while passing a monochromatic light beam of a select wavelength through the flame to a detector. The detector measures the final intensity of the beam and the decrease in intensity is proportional to the concentration of the element in the solution.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Development of individual ion electrodes.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 to $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Advanced Plethysmograph

2. BRIEF DESCRIPTION. The development of an advanced plethysmograph.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Limb plethysmographs must be capable of continuous accurate measurement of the volume and/or changes in the circumference of both legs during various manipulations of the subject. They must be nonintrusive, nonrestrictive, and easily installed around the limbs.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current plethysmographs allow only an approximation of total limb volume by means of cross-sectional measurements of the limb by photoelectric impedance or strain-gauge measurements. The results are insufficiently accurate for the requirements of the spacecraft investigations.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). See Item 13.

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A new system has been designed by Webb Associates (Malibu, Calif.) and will be marketed by Physiometrics, Inc. (Malibu, Calif.). This design (Helix Girth Measurement System) utilizes a linear inductance transducer to detect limb volume changes. Initial testing indicates superior advantages over classical measurement techniques.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 to 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $25,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Mass Measurement Device

2. BRIEF DESCRIPTION. The study and development of a mass measurement device for small particles and biological specimens.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities; development.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A mass measuring device for small sections of biological tissues is required. Since these specimens are subject to loss of fluid and a degradation of biochemical activity, it is essential that the measurement be performed rapidly and not be destructive. This particular measurement will often be the first analytical measurement performed in an experiment. Since there will be no acceleration due to gravity, other physical laws which can permit mass measurements to be made must be examined and the most suitable applied to this requirement. The measurement devices should have a capacity of 1 to 3 gms with an accuracy of about ± 0.1 micrograms.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. All current devices are gravity dependent. The most accurate laboratory balances are the electrobalances as exemplified by the Cahn Electrobalance Model RG200 in which the sample is balanced by an electromagnetic torque and the coil voltage is measured by a precision potentiometer.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground and space laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 to 5 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Approximately $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Equipment Analysis and Integration

2. BRIEF DESCRIPTION. A study for equipment integration and analysis for a space biology laboratory.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). 50

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. All listed items are required for space biology experiments. Their current specifications are acceptable for the purposes of the defined experiments. The items of equipment include:

SPACE BIOLOGY EQUIPMENT

SPACE QUALIFICATION REQUIRED

1. Space Rated Spectrophotometer
2. Space Rated Gas Chromatograph
3. Space Rated Liquid Scintillation Counter
4. Space Rated Refrigerator - Freezer
5. Space Rated Compound Microscope

6. Space Rated Microtone
7. Space Rated Psychogalvanometer
8. Space Rated Implentable Blood Pressure Transducer
9. Space Rated Multichannel Biomedical Recorder
10. Space Rated Electromagnetic Flowmeter
11. Space Rated Light Discrimination Apparatus
12. Space Rated Flicker Fusion Apparatus
13. Space Rated Linear Motion Transducer
14. Space Rated Audio-Visual Tactile Stimulator
15. Space Rated Multichoice Stimulus Display and Recorder
16. Space Rated Audiometer
17. Space Rated Vacuum Infiltration Oven
18. Space Rated Potentiometer with 10^6 Ohm Input Impedance
19. Space Rated Refrigerated Centrifuge
20. Space Rated Camera — Still and Time Lapse
21. Space Rated Oscilloscope
22. Space Rated Electronic Thermometer
23. Space Rated Spirometer
24. Space Rated Paramagnetic Oxygen Analyzer

A study is required to integrate the above equipment into a space biology laboratory. This study should address such problems as reduction in weight, power and volume; human factors related to laboratory operations; analysis of materials to insure spacecraft compatibility (outgassing, flammability, etc.).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The function of all listed items should not be adversely affected by zero g. Their power, weight, and volume should, however, be reduced for spacecraft use and aspects of their construction should be modified for spaceflight qualification.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground-based laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. IMBLMS development program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 to 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 to 10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. High-Resolution Optical Systems.

2. BRIEF DESCRIPTION. Develop high angular resolution optical systems for use with electro-photographic sensors; astronomy imagery of small extended sources. (3 meter)

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO, -OP; (Important) 3-XR

4. ITEM NO(S). 3a, 51

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments in space and not in space to define present capabilities

6. OBJECTIVES. Theory; Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. System requirements: (1) angular resolution @ 5,000 Å, on axis centerline 0.04 arc sec (circle of confusion radius), off axis ± 7.5 arc min. 0.10 arc sec (circle of confusion radius); (2) 3-meter aperture, f/15, focal length 45 meters; (3) linear resolution, @ 5,000 Å -- on axis (centerline) = 110 line pairs/mm off axis (± 7 1/2 arc min) = 44 line pairs/mm; (4) exposure times expected 10 sec to 10 hrs (with image intensifier); (5) visual magnitude of subject 19 to 27.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Resolution is a system problem and must be developed as such. The space state of the art in most of the related technologies is unknown at this time, and particularly their interactions as a system. The final resolution is some function of at least the following error sources of which little is known for space applications: (1) residual optical aberrations (in space); (2) thermal

distortions in the optical system (in space); (3) alignment accuracy (in space); (4) focus accuracy (in space); (5) differential aberrations due to relative velocity between the instrument and subject; (6) guidance (pointing) tracking signal characteristics; (7) guidance (pointing) servo characteristics (multistage); (8) availability of suitable celestial tracking sources; (9) servo velocity errors (for dynamic disturbances and slew rates on moving targets); (10) interaxis coupling between azimuth, elevation and roll axis of vehicle/telescope (these are different systems); (11) type and kind of celestial reference system used and accuracy of coordinate transfer system, if any; (12) exposure time (length of tracking interval); (13) physical disturbances affecting telescope stabilization; (14) disturbance isolation (minimization).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Must be coordinated with equipment, requirements and developments of related STD items A-2, -3, -5, -6, -8, -10, -11 and -13.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Requires (1) systems study to determine limits and relations of parameters and variables, (2) experimental tests a) on ground, b) in space to identify magnitudes and interrelations of variables, (3) trade studies to optimize system,and (4) development of identified STD specifics.

12. SPECIAL FACILITIES REQUIRED. (1) Cold Chamber (39 foot) where thermal effects of optics can be evaluated (ground); (2) vacuum optical tunnel for evaluating the state of art in Items 4, 6, 7, and 8 of Item 8; (3) space tests for evaluation of the state of the art in Items 2, 5, 6, 7, 9, 10, 12, 13, and 14 of Item 8; (4) servo lab for developing multiloop electro-optical mechanical servos.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Possibly Apollo telescope mount (ATM) Skylab A and B if studies started soon enough.

F

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
If advancement is optimized, i.e., studies, ground experiments, and developments are performed as near simultaneous as possible, total time should not exceed 10 years.*

15. FSTIMATE OF COST OF ACHIEVING ADVANCEMENT.
*$50 Million to $500 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT.
Low

*Resulting development vital to practically all present and future optical astronomy programs, many optical communication and/or navigation programs and some Earth observations programs. Time and costs shown above may be prorated across common items which would be available during an STD grouping, commonality, priority analysis.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. **Advanced Electronic Image Intensifiers**

2. BRIEF DESCRIPTION. Development of better performance electronic image intensifiers for astronomy.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB; (Important) 3-OS, -SO, -OP

4. ITEM NO(S). 3a

TYPE OF STD EFFORT

5. ACTIVITIES. Study to define present capabilities; Development.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. (1) spectral range 900 Å to 1μ; (2) photocathode size (minimum) 134 mm diameter (5.27"); (3) resolution:

106 LP/MM, centerline	Graduated
Edges of photocathode 43 LP/MM	Uniformly

   (4) luminous flux gain 50,000; and (5) magnification factor 1.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The present state of the art is ≈ as follows: (1) spectral range ≈ 3,000 to 7,5000Å (10% points); (2) photocathode size = 89 MM (3.5"); (3) resolutions: Center 28 line pairs/MM; edge 23 line pairs/MM; (4) gain - 3-stage cascade = 1.4×10^5 (radiant power) and (5) magnification = 1.
   The above data are based on laboratory devices (RCA-C70055GP2), and are both preliminary and tentative. Advances in photocathode size, resolution, and extended spectral range are indicated as possibilities but would require special developments. Much of the data is classified.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Must be coordinated with equipment requirements and developments of related STD items A-1, -7, -8, -9 and -11.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Specialized technologies in electron optics and phosphor and photocathode materials.

12. SPECIAL FACILITIES REQUIRED. No special equipment other than existing in present laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Most photo electronic manufacturers - RCS, ITT, Westinghouse, General Electric, Sylvania, etc. - Much of the development is classified. Best source - RCA, Lancaster, Pa.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Telescope Operation in Space

2. BRIEF DESCRIPTION. Operational developments for high-resolution optical astronomy telescopes. Acquisition of targets - operational concepts and equipment.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO, -OP, -XR; (Important) 3-LF

4. ITEM NO(S). 3A, B, C

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments not in space to define present capabilities

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Instrument is remote, passive, and outside space research facility; (1) acquisition - initial directing of optics to celestial target (see Appendix J); (2) Celestial coordinate system requirements: indefinite (see Appendix J).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The state of the art in telescope pointing (target acquisition) is essentially unaddressed. Few, if any concepts, are in evidence and some of the problems are formidable. The subject is critical. There are many STD items involved depending upon the acquisition concept -- These include new sophisticated navigation systems with possible accuracies in the 10^{-3} arc-sec category to upgraded gyro reference system using new computers and transformation systems. Studies are certainly in order with good possibilities of spaceflights, or at least simulators, to determine remote operation by man.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Must be correlated with operations, equipment and systems of STD items A-1, -5, -6, -8, -9, -10 and -13.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Trade studies (1) relation to earth as reference, involves earth position sidereal time and attitude; (2) elevation/azimuth system related to attitude relative to earth; and (3) uses 2 gyro system, references: celestial equator and vernal equinox.

12. SPECIAL FACILITIES REQUIRED. Will probably require simulator for operator training, at least, and possibly for development and evaluation of remote control system used.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None known

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 months study, 6 months definition of equipment and 1 additional year if simulator required. Minimum time - 1 Year; maximum 2 Years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

Study only	$250,000
Simulator	$500,000*
TOTAL	$750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

*May be integrated with 3-OW - A-7

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Orbit-to-Orbit Shuttle Requirements

2. BRIEF DESCRIPTION. Study to determine requirements of a shuttle to transport men and consumables to the Low-Frequency Radio Observatory.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO, -XR; (Important) 3-LF

4. ITEM NO(S). 6, 41, 43, 44, 68

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The role of man in this experiment is limited to repairing electronics or replenishing consumables aboard the Low-Frequency Observatory. A shuttle is required for transportation to synchronous or greater altitudes. The Low-Frequency Observatory cannot operate below 10,000 km altitude. This study should also relate to the requirements of Research Clusters 3-OW, 3-XR, 3-OB, and 3-OS.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. State-of-the-art essentially unaddressed. Requirements above are marginal and require further study (1) a study defining man's role is needed (2) a set of shuttle specifications must be derived, (3) the space state-of-the-art must be determined.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A-6, A-7

11. SUGGESTED DEVELOPMENT APPROACH(ES). Integrate with Orbit-to-Orbit Shuttle studies.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Orbit-to-Orbit Shuttle Study (NASA/NAR)

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Assembly and Alignment of High Resolution Telescope in Space

2. BRIEF DESCRIPTION. Assembly and deployment of 3-meter telescope in space (EVA).

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO, -XR; (Important) 3-OP

4. ITEM NO(S). 3A, B, C

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities.

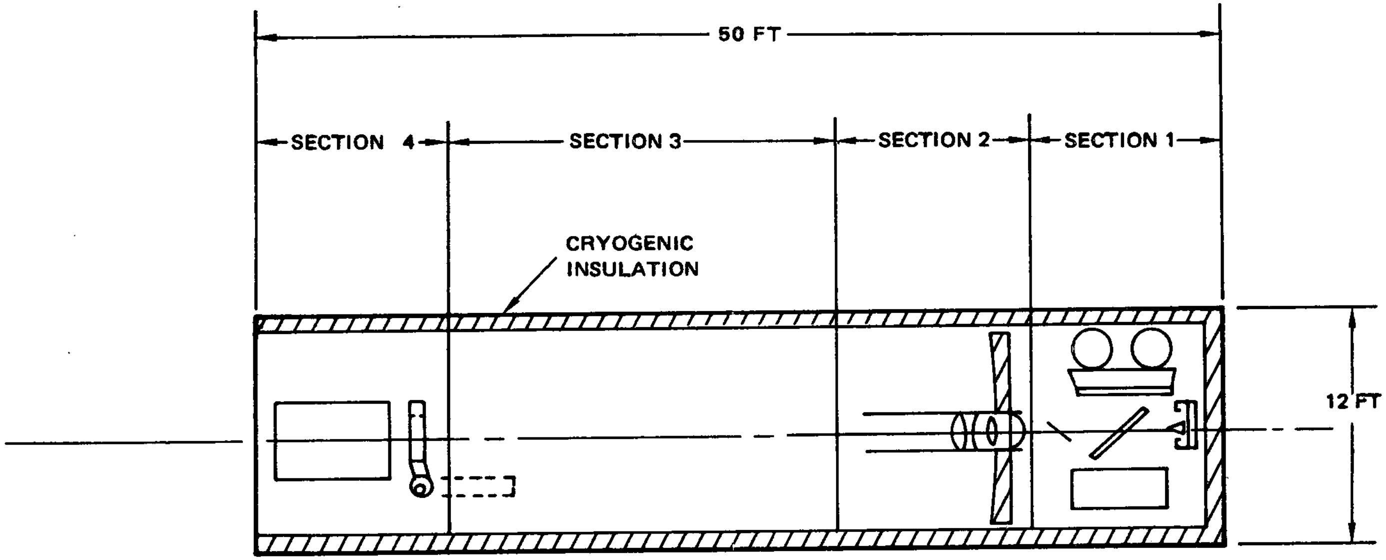
6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Experiment envisions telescope delivered to space in 4 sections shown on accompanying diagram. Astronauts (3) will move sections into position, attach and adjust for operation. Optical surfaces to be covered at all times (3 layer "lens" caps) except when in use. Prime focus, alignment $\pm 1:6x10^8$ in (f/3). Cassegrain focus, alignment $\pm 1:2x10^5$ in (f/15). Tilt and lateral motions unknown. All corrections to be made by secondary mirror - 5 degrees of freedom through electric motors. Secondary mirror motor driven to swing 90 degrees when changing from prime to Cassegrain.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Low. Requires study for basic feasibility and subsequently,

E-159A



SECTION 1—INSTRUMENT SECTION
- SPECTROSCOPE
- CAMERA(S) PHOTOGRAPHIC
- PHOTOMETER
- BEAM SPLITTER (TRACK AND FOCUS)
- BEAM SPLITTER (TV CAMERA FOR ACQUISITION)
- TV CAMERA
- TRACK DETECTOR

SECTION 2—MAIN OPTICS
- 3 METER MIRROR
- MIRROR SUSPENSION
- RITCHEY CHRETIEN FIELD CORRECTORS
- CRYOGENIC COOLED BAFFLE TUBE
- AUTOMATIC/REMOTE LENS CAPS

SECTION 3—STRUCTURE
- STRUCTURE ONLY

SECTION 4—SECONDARY OPTICS—PRIME FOCUS
- RETRACTABLE SECONDARY MIRROR
- SEC. MIRROR FRAME AND MOTORS (5 DEGREES OF FREEDOM)
- INSTRUMENTATION BOX
  - DATA COLLECTION AT PRIME FOCUS (SECTION 1)
  - TRACKING DETECTOR AND ELECTRONICS
  - BEAM SPLITTER
  - ROTATING MIRROR
  - FOCUS DETECTOR
  - FOCAL PLANE MOVING MOTOR
  - ROSS FIELD CORRECTOR
  - CALIBRATION DEVICES
  - TV CAMERA AND ALIGNMENT EQUIPMENT
  - AUTOMATIC/REMOTE LENS CAPS

Figure 3-OW. 3-Meter Optical Telescope Group

FIGURE 3-OW. 3-METER OPTICAL TELESCOPE GROUP

concepts for trade configurations. Many unaddressed problems. Confidence in their solution good except for:

Low: astronaut assembly operations in space refurbish, resupply and logistics operation

Very low: initial alignment and adjustment to accuracy required continued alignment problems during operation

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A-1, -3, -6, -8, and -11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Needs study, problem has many alternate approaches and hence trade studies--some space and ground tests may be required (simulated assembly and alignment).

12. SPECIAL FACILITIES REQUIRED. Optical laboratory (on ground).

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 3-OW, A-1

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
    A. Study, 18 Mos.
    B. Ground tests, 18 Mos.
    C. Space tests, 2 Mos.

    38 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
    A. $500,000
    B. $1 Million
    C. $5 Million

    $6.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Low

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Developments For Use of High-Resolution Telescopes (Operational)

2. BRIEF DESCRIPTION. Operational developments for high-resolution - optical astronomy telescopes - remote unit, operations, logistics control, data, retrieval and handling, maintenance, service, calibration, and repair.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO; (Important) 3-LF, -OP, 1-BR-1-3, -3, -4, 1-MM-1

4. ITEM NO(S). 3A

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. General remote operation (sync orbit): (1) man-visited, but unmanned operation (remote control) of detached satellite at synchronous orbit (19,000 nmi or at least 600 nmi); (2) manned visit to; maintain, repair, and change instruments (Imagery, Photometry, Spectroscopy - UV-IR); (3) remote operation: calibrate and adjust, take data, and process and evaluate data; (4) logistics: retrieve and resupply film, and resupply expendables.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The four main categories above have mainly been unaddressed. All the purposes for man visiting a detached satellite are not entirely clear. Resupply of film and expendables is

understandable but at present no detail requirements are available; i.e., how often, when, how much? Maintenance and repair are even less definitive as to what might be done, how, when, where, and why. Among these are possible causes of maintenance and repair as man's extension to synchronous orbit could be difficult and expensive. The changing of instruments and their calibration is another matter. To consider this as a remote operation (particularly calibration) is most desirable as man's presence could easily disturb the precise adjustments required. However, automating or controlling these operations by remote control may require some exceedingly sophisticated equipment. Particularly when the remote link may be 20,000 nautical miles long.

Much of this detail is buried in general requirements specified by the scientist for measurements of various types. High altitude orbits for astronomy are required partly to obviate the effluent plumes or plasma around manned space research facilities and lessen occultation of the celestial sphere by the Earth.

This presents logistics, communication, control, maintenance, service, and operational problems of the instrument facility in space. The concepts of operation of such equipment is sophisticated and complex and should encompass a separate trade study to even determine a reasonable feasibility.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A-1, -3, -5, -8, -11, -12 and -13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study phase to determine feasibility, trades and system and operational requirements.

12. SPECIAL FACILITIES REQUIRED. Possible use of simulator for target acquisition and automatic data processing (man commanded).

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Study phase 6 months, definition phase 6 month - 1 year.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

Study only	$250,000
Simulator	$500,000*
TOTAL	$750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

*May be integrated with 3-OW

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Development of Use of Photographic Film for Space Astronomy

2. BRIEF DESCRIPTION. Operational development of high resolution-optical astronomy telescopes - The protection and use of photographic film in a null gravity, vacuum, high-radiation environment.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -SO, -XR; (Important) 1-BR-1-3, -3, -4, 1-MM-1

4. ITEM NO(S). 3A

TYPE OF STD REPORT

5. ACTIVITIES. Study; experiments in space to define present capabilities; development.

6. OBJECTIVES. Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7, REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.

   A. Protection of photographic film in space.
      - Vacuum environment
      - Radiation (fogging)
      - Thermal limits
      - Change of sensitometric qualities with time

   B. Processing of photographic film in null gravity.
      - Dry: Bi Matt/Poloroid - quality, size
      - Wet: Shumann type (to λ 50 Å)

   C. Use of photographic film in space:
      - Resolution to 100 LP/MM
        sensitivity P-20 image intensifier screen
      - Film size 8" x 8" (1° field)
      - Film to be flat in film plane to diffraction limit

G

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Vacuum environment, ground tests appear satisfactory for polyester base. Radiation fogging serious with little known about protection. Thermal limits are narrow (70°F ± 40°F). No knowledge of methods, equipment, or techniques for processing in null gravity. Resolution of image intensifier low (28 lines/min), screen size too small, film size (8" x 8") too large for image tube, unknown for processing with Bi Matt process and conditions do not allow holding film plane flatness (prime focus accuracy $\pm 4.4 \times 10^{-5}$ inches required) Kodak micro-flat glass (0.250" thick) up to 8" $\approx 5 \times 10^{-5}$ of curvature per linear inch of diagonal.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A-2, -3, -4, -5, -8 and -11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Requires study before development can be defined.

12. SPECIAL FACILITIES REQUIRED. See Section on photographic film protection and processing laboratory (3-05, item 5).

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Possible Skylab/ Space Station, etc., if time phased and funded properly.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.

A. Study 2 mo., + design and fab functions 5 mo., + space test 2 mo. = 9 mo.
B. 8 mo.
C. Upgrade filter techniques - 6 mo.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

A. \$40,000 + \$150,000 + \$200,000 = \$390,000
B. \$200,000
C. \$100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT.

High	Medium	Low
Film sensitivity stability	Schumann emulsion processing	Film flatness
Vacuum environment	Radiation protection	Image intensifier surface flatness
	Thermal limits	

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. High-Resolution Optical Telescopes

2. BRIEF DESCRIPTION. Develop high-angular-resolution optical systems for use with electro photographic sensors to detect and measure faint known, predicted, or previously unobserved objects. (1 meter)

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OS, -OB, -OS, -SO; (Important) 3-XR, -OP, 1-BM-4

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities; development.

6. OBJECTIVES. Theory; Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.

A. 1-meter-aperture diffraction-limited telescope
B. f/3 prime; f/12 compound
C. Both prime and Cassegrain foci to be used
D. Resolution: angular:

0.1 arc sec at 4,000 Å
edges .6 arc sec (Cassegrain)
8.2 arc sec (prime)

E. Linear:

665 L/MM
edges 82 L/MM } --prime
167 L/MM at λ 4,000 Å
edges 27 L/MM } --Cassegrain

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Resolution is a system problem and must be developed as such. The space state-of-the-art in most of the related technologies is unknown at this time and particularly their interactions as a system.

The final resolution is some function of at least the following error sources of which little is known for space applications: (1) residual optical aberrations (in space), (2) thermal distributions in the optical system (in space), (3) alignment accuracy (in space), (4) focus accuracy (in space), (5) differentail aberrations due to relative velocity between the instrument and subject, (6) guidance (pointing) tracking signal characteristics, (7) guidance (pointing) servo characteristics (multistage), (8) availability of suitable celestial tracking sources, (9) servo velocity errors (for dynamic disturbances and slew rates on moving targets), (10) interaxis coupling between Azimuth, elevation, and roll axis of vehicle/ telescope (these are different systems), (11) type and kind of celestial reference system used and accuracy of coordinate transfer system, if any, (12) exposure time (length of tracking interval), (13) physical distrubances affecting telescope stabilization, and (14) disturbance isolation (minimization).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Must be coordinated with equipment, requirements, and developments of related STD items A-1, -2, -3, -5, -6, -10, -11 and -13.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Requires (1) systems study to determine limits and relations of parameters and variables, (2) experimental tests on the ground, and in space to identify magnitudes and interrelations of variables, (3) trade studies to optimize system, and (4) development of identified STD specifics.

12. SPECIAL FACILITIES REQUIRED.

A. Cold chamber (39 foot) where thermal effects of optics can be evaluated (ground).
B. Vacuum optical tunnel for evaluation the state-of-the-art in Items 4, 6, 7, and 8 of Item 8.

C. Space tests for evaluation of the state-of-the-art in Items 2, 5, 6, 7, 9, 10, 12, 13, and 14 of Item 8. Servo lab for developing multiloop electro-optical mechanical servos.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Possibly Apollo telescope mount (ATM) Skylab A and B if studies started soon enough.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. If advancement is optimized, i.e., studies, ground experiments, and developments are performed as near simultaneous as possible total time should not exceed 10 years.*

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50 Million to $500 Million.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Low

*Resulting development vital to practically all present and future optical astronomy programs, many optical communication and/or navigation programs and some Earth observations programs. Time and costs shown above may be prorated across common items, which would be available during STD grouping, commonality, priority analysis.

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Electronic Image Intensifiers

2. BRIEF DESCRIPTION. Development of better performance electronic image intensifiers for planetary astronomy.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 3-OW, -OB, -OS, -SO, -OP

4. ITEM NO(S). 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study; development.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.

   A. Spectral range 2, 000 Å - 1
   B. Photocathode size (maximum) 27 mm (1.06") diameter
   C. Resolution (f/75 at 5, 000 Å D. L.)
      21 L/MM
   D. Luminous flux = 50, 000 (minimum)
   E. Magnification factor = 1

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The present state-of-the-art will meet all requirements except spectral response. Limits at present are ≈ 3, 100 Å → 7, 500 Å (10% prints). See STD number A-2 under experiment group 3-OW.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Must be coordinated with equipment requirements and developments of related STD items A-1, -7, -8 and -11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Specialized technologies in phosphor and photocathode materials.

12. SPECIAL FACILITIES REQUIRED. No special equipment other than existing in present laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Most photoelectronic manufacturers -- RCA, ITT, Westinghouse, General Electric, Sylvania, etc. Much of the developments are classified -- best source - RCA, Lancaster, Pa.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Acquisition of Celestial Targets

2. BRIEF DESCRIPTION. Methods, techniques and equipment for use in acquiring specific astronomical targets in the celestial sphere.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -OB, -OS, -OP, -XR, -LF; (Important) 3-SO

4. ITEM NO(S). 51

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities; development

6. OBJECTIVES. Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Point to any position of the sky on command such that a target of 26th magnitude will be placed on the optical axis of the telescope within ± 1 arc second.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Several methods of target acquisition have been used: (1) establish sun line, revolve vehicle (telescope) around this line to a specific star -- target is referenced to these coordinates; (2) establish local meridian, sidereal time, celestial equator and vernal equinox; (3) establish celestial equator and vernal equinox references; (4) present method on ground using modifications of (2) with man in loop for final positioning -- present state-of-the-art in open pointing without man (Palomar Hale 200" ≈ ± 7 arc-min.).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED.
A-1, -3, -6 and -9

11. SUGGESTED DEVELOPMENT APPROACH(ES). Will require trade studies for feasibility, cost, complexity, reliability, and accuracy. Four approaches are indicated in Item 8.

12. SPECIAL FACILITIES REQUIRED. Ground simulator, or use of a small ground astronomy observatory modified to examine the trade options.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.

Study -	9 Months	
Design -	9 Months	-- 24 Months*
Simulation-	6 Months	

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

Study -	\$200,000	
Design -	\$400,000	-- \$700,000*
Simulator -	\$100,000	

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

*These figures can vary widely depending upon results of study and integration with other STD programs. The figures indicated are a best estimate "mean" of the problem.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. High Precision Stellar Photometry

2. BRIEF DESCRIPTION. Concept and development of better precision (higher sensitivity - less noise, higher photmetric resolution) photometers, observational techniques, and sampling procedures.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OP; (Important) 3-OW, -OB, -OS

4. ITEM NO(S). 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments not in space to define present capabilities; Development.

6. OBJECTIVES. Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.

   A. System Requirements -- Photometric resolutions better than 10^{-4} magnitudes: (increased sensitivity, lower noise, increased gain stability in sensor and associated circuitry if required, improvement in time constants at low light levels, lower hysteretic effects - photocathode fatigue - power supplies - and amplifiers).
   B. New Observing Techniques -- Study and verification of new and present techniques for use in space to improve the photometric/time relationship.
   C. Develop Sampling Procedures -- Improve observational sampling procedures to reduce monitoring time of large numbers of stars and rare events.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present state-of-the-art is essentially unaddressed for space.

A. Ground based stellar photometry limited to 10^{-3} magnitude due to atmospheric scintillations.
B. Unaddressed area for space.
C. Unaddressed area for space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. **OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. RELATED to Std. Items A-1, 2, 8, 9, 10.**

11. SUGGESTED DEVELOPMENT APPROACH(ES).

A. None
B. None
C. None

12. SPECIAL FACILITIES REQUIRED. None other than those already in existence within the industry.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.

A. 18 Months (mostly component development)
B. 9 Months (study)
C. 9 Months (study)

36 Months Total (can be concurrent).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

A. \$200, 000
B. \$100, 000
C. \$100, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cooling of Solar Astronomy Telescopes

2. BRIEF DESCRIPTION. Development of solar energy attenuaters external to a solar telescope and means of removing the attenuated energy to an external heat sink.

SOURCE FROM WHICH THIS STUDY REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-SO; (Important) 3-OW, -OS, -OP

4. ITEM NO(S). 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities; development.

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Requirements: cooling of solar telescope and instruments (1) in order to keep the heat balance within the optical parts of the telescope within acceptable diffraction limited limits, most of the heat from the sun (145 watts/sq ft) must be kept from entering any part of the telescope, (2) the excess heat (energy) not entering the telescope system must be conveyed to an external heat sink.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. State-of-the-art: Solutions to this problem have been addressed principally by Questar*. A thin glass plate in a ventilated cell is placed over the full aperture of the telescope tube (3. 5 inches). The plate attenuates the light by a factor of 50, 000 through the use of a deposited layer of chromium on the front glass. The glass plates are manufactured to 0. 1 wavelength and plane parallel to one second of arc. This problem is essentially unaddressed for large (1 meter) space telescopes.

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*Questar, Box 120, New Hope, Pennsylvania, 18938

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Noted under Item 8. However, spectral response will be limited in the UV and near IR. Manufacture of cells to the accuracies required in sizes above 60 in. is somewhat doubtful at this point in time.

12. SPECIAL FACILITIES REQUIRED. Ground test facilities: Sun simulators capable of projecting a beam essentially collimated over a 2-2.5 meter diameter and having a spectral response from 1,000 Å to 1μ.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.

A.	Study - 6 Months	30 Months Total
B.	Fabricate and test - 1 Year	
C.	Possible upgrading of simulator or use of sun itself - 1 Year	

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

A.	\$ 75,000	\$575,000 Total
B.	\$200,000	
C.	\$300,000	

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Acquisition and Tracking of Solar Targets

2. BRIEF DESCRIPTION. Development of precision acquisition and tracking of solar targets (dynamic - high precision positioning while slewing).

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OB, -SO; (Important) 3-OW, -OS, -OP

4. ITEM NO(S). 4

TYPE OF STD REPORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities; development.

6. OBJECTIVES. Theory; Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Acquire (point telescope) Sun in telescope field and center object of interest in Sun's surface on center line within a circle less than 1 arc minute in diameter for imagery, and less than +0.05 arc sec for spectroscopy. Guide or track spot on Sun (dynamic - slewing servos) of interest to less than +0.05 arc-sec.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. State-of-the-art is essentially unaddressed.

   A. The Earth intercepts solar energy at zenith of 1,350 watts per square meter. With a 1.5 meter (minimum) opening in the telescope approximately 2400 watts enter the telescope. From 15% to 40% of this will be absorbed by the primary and secondary mirrors and the remainder on the detector spectroscope jaws

C 3

and/or optics in the path when the solar disk is centered in the telescope field. During acquisition, however, the image of the Sun will fall on the side walls and other structural parts which are treated to absorb stray light and probably over 99% of the solar energy will be directed to baffles, and hence, to structure which can produce most difficult conditions for alignment and maintaining diffraction limited performance of the instrument.

B. Guidance or tracking of the telescope on the sun is an entirely different problem than that of a point source. Elements of the 1/2-degree-wide image of interest are within the photosphere and chromosphere; features such as sunspots, plages, prominences and spicules. These features are in constant dynamic motion with displacements far in excess of the tracking guiding requirements, and certainly larger than the diffraction limit capability of the telescope. In fact this is the reason for the large diffraction-limited optics and cinematography to enable studies to be made of the dynamics in detail.

Unless a separate star tracker of large aperature is used (at least 1 meter diffraction-limited) stars of at least +1 visual magnitude will be needed for tracking through the 50, 000:1 attenuating filter. Furthermore, regardless of the method, the angular seperation must continually change in a calculated open loop manner. Perhaps some local-area averaging system can be conceived which will be satisfactory during some types of observations.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A-10, A-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Other than described for Questar, the problem is essentially unaddressed.

12. SPECIAL FACILITIES REQUIRED. Solar simulator (as described) or equivalent facility using the Sun itself.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.

A. Study - 9 Months B. Fabrication and testing - 18 Months C. Testing facilities - 12 Months	} 39 Months Total

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.

A. \$150, 000 B. \$250, 000 C. \$200, 000	} \$600, 000 Total

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Mass Spectrometer

2. BRIEF DESCRIPTION. The development of a space-qualified mass spectrometer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PC-1

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Experiment calls for observation of combustion processes in a combustion chamber at various oxygen pressures. The experiments proceed from the simple to the more complex as follows: (1) burn various solids (paraffin, nylon, polymethyl, methacoylate) at various partial pressures of oxygen, (2) burn liquid hydrocarbons (aliphatic and aromatic species) as in previous item, (3) impinge N_2O_4 and N_2H_4 at various mixture ratios, and (4) observe change of characteristics at various oxygen partial pressures. This instrument must have the capability of responding to many kinds of materials since the kinds of materials being burned will probably change with time. A study is required to determine the threshold response and accuracy required based upon the anticipated reaction products and the desired instrument flexibility.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Study will draw on currently available knowledge concerning spectroscopy.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-2

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Existing laboratory and test facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Gas Chromatograph

2. BRIEF DESCRIPTION. The development of a space-qualified gas chromotagraph.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PC-1, -4

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A study is required to specify: (1) the required sensitivity (2) what gases might be found, (3) the number and type of gas columns to be provided, and (4) the detector sensitivities. The aim is to provide a lightweight, compact, space-rated gas chromatograph to meet the experiment requirements and also provide the necessary flexibility for growth.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Study will draw on currently - available knowledge concerning chromatography.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important - some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-4

11. SUGGESTED DEVELOPMENT APPROACH(ES) None

12. SPECIAL FACILITIES REQUIRED. Existing laboratory and test facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Pyrometer

2. BRIEF DESCRIPTION. The development of a self-balancing, low-temperature, optical/IR pyrometer with fast response (0.1 second) and digital readout.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-1, 4-P/C-7

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A space-qualified optical/IR pyrometer is required which has the following characteristics: (1) measures temperatures from 20°C to 2000°C with capability to 2800°C using filter, (2) response time < 0.1 second, (3) digital/recorder readout, and (4) automatically self-balancing.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An optical/IR pyrometer exists (Raytech Co.) which measures from about 20° to 2,000°C with 0.1 sec response but must be manually balanced. Also, the readout is a dial, not the required digital type.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-31

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Apparatus for Liquid/Vapor Studies

2. BRIEF DESCRIPTION. The development of an experimental apparatus for liquid/vapor interface studies.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-2

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This STD item consists of two activities. The first is a study to assess the impact of zero-g operation on the apparatus and to outline the human factors requirements. The second is the actual development of the apparatus which consists of tanks with viewports, sloshing devices, removable baffles and necessary plumbing, all of which must SAFELY operate with fuels, cryogenic liquids, etc., under manned orbital conditions. In addition, a special liquid drop rotating device, capable of speeds up to 12,000 rpm, must also be developed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This apparatus exists only as special, one-of-a-kind laboratory apparatus for use in 1-g environments.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-7

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Existing laboratory and test facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months (for study). 18 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$100,000 (for study). \$1 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Low-G Accelerometer

2. BRIEF DESCRIPTION. The study and experiments related to development of low-g accelerometer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-2, -3, -6, -7, -10, -11; (Important) 4-P/C-4, -5

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A theoretical study to determine which phenomena are the strongest functions of the gravity level, determination of the technological feasibility in terms of required power and support equipment. Must respond to 10^{-6} g-level with ± 1 percent accuracy.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Accelerometers are available in the range 10^{-3}g level and a theoretical understanding of the use of capillary and superconducting levitation effects* in measuring gravitational fields.

*For example, see "A Superconducting Gravimeter," in the Proceed. of Symposium of Superconducting Devices, April 1967, University of Virginia, Charlottesville, Va.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-6, P-11, P-22

11. SUGGESTED DEVELOPMENT APPROACH(ES). Applicability of present devices to range of 10^{-6} g-level should be evaluated and new techniques such as capillary rise height and superconducting levitation should be investigated.

12. SPECIAL FACILITIES REQUIRED. Low-g nonspace simulation as well as in-space testing platform.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (for study). 12 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 (for study). $500,000 (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Low-G Isolation Mounts

2. BRIEF DESCRIPTION. The study and experiments related to development of low-g isolation mounts.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-2, -3, -4, -5, -6, -7, -10, -11; (Important) 4-P/C-1, -8, -9

4. ITEM NO(S). Question No. 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory of low-g impulse and vibration insolation and the use of current materials and techniques (or anticipated future materials) to provide isolation of vibration of the order of 10^{-6}g. The use of techniques other than mechanical (e.g., levitation) is also required. Space tests will be required to determine the effectiveness of the isolation mounts in an actual manned-vehicle environment. The initial development and testing can be done on the ground.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory of shock and vibration isolation by mechanical means is well understood; the use of levitation techniques can be determined by a study of magnetic fields (possibly using superconducting magnets).

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PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-5, P-11, P-22

11. SUGGESTED DEVELOPMENT APPROACH(ES). A study of the applicability of mechanical versus levitation techniques should be established.

12. SPECIAL FACILITIES REQUIRED. An earth laboratory could be used for testing in the initial phases with a space laboratory being essential for the operational checkout phase.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Crystal Growing Apparatus

2. BRIEF DESCRIPTION. The development of a space-qualified crystal growing apparatus.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-6

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The required characteristics are as follows: (1) uses Czochralski crystal pulling method, (2) crystal diameters up to 5 cm, (3) rotation speed and expected growth rate are subjects for study, and (4) $\pm$ 0.5^{o}F temperature stability, over 400^{o} to 4,000^{o}F range.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Czochralski crystal pulling devices exist only for ground-based operations.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-8

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months (for study). 1 Year (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 (for study). $500,000 (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Zone Refining Apparatus

2. BRIEF DESCRIPTION. The development of a space-qualified zone refining apparatus.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-6

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A space-qualified zone refining heater is required. However, zero-g application is not straightforward because Heywang's relation for the reaction length, ($\ell = 2.8\ (\gamma/\rho g)^{-1/2}$) predicts an infinite length at zero-g.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theoretical studies are underway concerning these zero-g effects. Apparatus exists for use in 1-g environment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-7, P-9

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Production of Hard Vacuums

2. BRIEF DESCRIPTION. An assessment of the problems associated with achieving vacuums $> 10^{-8}$ Torr for apparatus associated with a large orbital research facility.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-6; (Important) 4-P/C-8

4. ITEM NO(S). Question No. 4 of Synopsis.

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space to define present capabilities.

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Various space physics experiments (e.g., 4-P/C-6 and 4-P/C-7) require vacuums greater than 10^{-8} Torr. Because of effluent-induced artificial atmospheres surrounding large orbiting vehicles, achievement of such vacuums may require more than simple venting. It may be necessary to extend the apparatus or the vent pipe away from the vehicle, fly the apparatus in a remote module, or use auxiliary pumps. Studies are required to evaluate the above options and to theoretically determine particle densities, diffusion rates and electric-charge effects. Experiments in space may be required to evaluate the artificial atmospheres of particular vehicle configurations.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The basic theory of diffusion and electrostatic attraction is well understood. However, before the density of the artificial atmosphere can be estimated, the gas species must be known. This and other configuration-peculiar effects complicate the problem by reducing the generality of the solutions.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-10

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years (one year of initial study plus one year of study/experimentation relating to particular configuration).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000 (assuming $200,000 for initial study).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Contamination by Physics Apparatus

2. BRIEF DESCRIPTION. A study to determine contaminative effects of experimental apparatus venting to space or extended through airlocks.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 3-OW, -0B, -OS, -XR; (Important) 4-P/C-6, -8, 4-PP-2-1

4. ITEM NO(S). Question No. 4 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. If hot, outgassing physics apparatus is to be operated outside an orbital research facility or vented to space, the deletrious effects of these experiments upon other experiments and the vehicle itself must be known. Such effects would include film deposition upon optical surfaces, light scattering by particles floating in the effluent atmosphere and contamination of observed spectra. A study, followed by experimentation and concluded with operational recommendations is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Diffusion properties of atoms and molecules in a vacuum are well known. The nature of the diffusing material must be specified and the effect upon optical surfaces, antennas, etc., must be experimentally determined.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-9, P-12

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A large vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Melting Apparatus

2. BRIEF DESCRIPTION. The development of a space-qualified melting apparatus with variable g-force capability and integral airlock.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-7; (Important) 4-P/C-4, -5, -6

4. ITEM NO(S). 6, and Question No. 4 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Apparatus is required which will enable materials to be levitated and melted in a chamber. The device must be capable of reaching temperatures as high as 3,500°C and monitoring these temperatures within 5°C. (This implies a 5 kw electrical load.) A spherical ingot up to 5 cm diameter must be accommodated. In addition, an airlock may be required for evacuating the chamber.

   A study is required to determine the best way (electric, magnetic, or mechanical) for levitating the samples. The samples will include conductors, insulators, magnetic, and nonmagnetic materials. Various methods for achieving variable g-forces will also be evaluated (chamber-within-a-chamber, isolation mounts, etc.).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is adequate for carrying out this study.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-5, P-6, P-22, P-24

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A large vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (for study). 12 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 (for study). $1 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sample Centering Device

2. BRIEF DESCRIPTION. A study to determine the best way of keeping levitated samples centered within experimental apparatus.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-5, -6, -7

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some means is required for centering and keeping centered various levitated samples related to physics experiments. Disturbances arising from atmospheric drag, stray magnetic effects, electrostatic effects, and outgassing must be neutralized. The relative degradation arising from these effects will depend upon the levitation mechanism chosen. Levitated samples will be up to 5 cm diameter (spherical) and weigh up to 50 grams. A centering accuracy of ± 2.5 cm will allow the sample to be readily viewable through the planned 15 cm viewports.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The study is within the-state-of-the-art.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-14

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Film Drawing Experiments

2. BRIEF DESCRIPTION. Space experiments to outline hazards associated with use of a device for drawing films from molten metal in zero-g.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-8

4. ITEM NO(S). Question No. 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Severe operational and safety problems arise in relation to the handling of molten metals in zero-g. (See STD Item P-17.) The exact nature of these problems is not yet clear but they are felt to be severe due to the proximity of the astronaut/experimenter to the molten metal. (It is required that he physically dip into the melt.)

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The device exists but must be qualified for space. Very little is known about the safety problems related to handling molten metals in zero-g.

C

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-14, P-17

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Safety aspects should be tested in space; a large vacuum chamber may be adequate for equipment evaluation.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Optimum Material Heating

2. BRIEF DESCRIPTION. A study to determine optimum way for heating or melting materials in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-4 through 4-P/C-8

4. ITEM NO(S). Question No. 4 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Component; System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An optimal method (in terms of weight, power, and crew safety) should be found for melting (or just heating) materials related to the space physics experiments. Peak powers up to 20 kw are anticipated with temperatures to 3,500°C. Volumes are about one cubic meter.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Candidate methods might include electrical (ohmic) heating, laser, or electron bombardment or solar heating.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cosmic Ray Experiment Package

2. BRIEF DESCRIPTION. The development of integrated experiment package to meet requirements of cosmic ray physics experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-CR-1 through -10

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This experiment package must be capable of meeting all requirements of the Cosmic Ray Physics Experiment Group. It must measure: (1) charge, -100 to +150 units at various accuracies; (2) energy, 10^8 to 10^{15} ev ± 1 to 100 percent accuracy; (3) momentum, 10^{-19} to 10^{-11} kg m/sec; (4) proton mass, 1 to 300 mass units, ± 0.5 for A=1 to 4; (5) incidence angle, 0 to 2π radians, ± 1 m radian; and (6) cross section, 10^{-27} to 10^{-40} cm^2, ± 10 percent to 100 percent. Some of these items are directly measured, others are calculated. This instrumentation should be developed under the direct supervision of the Principal Investigator.

   A study is required to ensure that a near-optimum integration is achieved.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Except for the transition radiation detector (see STD No. P-27) the present state-of-the-art is sufficient but integration into a package will require special efforts. Required instruments include superconducting magnet, ionization, spectrograph, total absorption counters, spark chambers, scintillation counters, Cerenkov counters, proportional counters, streamer chamber, liquid hydrogen target and transition radiation detector.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-27

11. SUGGESTED DEVELOPMENT APPROACH(ES). Principal Investigator should develop this equipment.

12. SPECIAL FACILITIES REQUIRED. Unknown

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months (for study). 24 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 (for study). $10 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Laser Holography

2. BRIEF DESCRIPTION. A study to determine value of holography and methods of implementing for droplet experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-9, 6-M-4

4. ITEM NO(S). 31, 53, 54

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A recorded laser hologram would enable a spinning drop to be studied at leisure on the ground from various aspect angles. The specific type of laser and recording medium are subjects of this study. Although the requirement in 4-P/C-9 is only for high speed photography, the three-dimensional picture obtained with holography will significantly improve the data evaluation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Laser holography has been proposed for the MDAC-West Cloud Chamber Experiments. CBS and RCA will market home laser playback units by 1972. The technique is proven.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-19

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Contaminant-Proof EC&LS System

2. BRIEF DESCRIPTION. Development of an EC&LS System which will enable safe handling of hot, noxious fluids and/or gases related to the physics experiments

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-1 thru 4-P/C-10, 2-VB-1, -2, -3, 2-IN-1, -2, -3, 2-P/T-1, -2, -3

4. ITEM NO(S). 2, 3, and 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities; development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some space physics experiments require zero-g handling of molten metals, volatile (toxic) fluids and hot apparatus (crucibles, etc.) In addition, some studies require observation of flame fronts and combustion profiles. The EC&LS system must be able to react to any emergency which may arise during these operations. Besides leak and contaminant-level sensing, a rapid fire-extinguishing system and a means of quickly localizing the hazard are required. The lack of gravity introduces some unique problems; i.e., how would one handle a free floating glob of molten aluminum? What are the clean-up problems if the lab is flooded to put out a fire?

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current EC&LS systems can detect certain isolated contaminants (CO_2 for example) but this capability must be broadened to include any contaminant likely to escape. Present fire-extinguishing systems may be adequate. Obviously, we have no operational experience in much of this area.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Laboratory facilities for testing and evaluating various concepts; possibly need large vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 48 Months (24 month study and experimentation, followed by 24 month development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$10 Million (\$1M study, \$3M experimentation, \$6M development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Heat Transfer Chamber

2. BRIEF DESCRIPTION. The design of an experiment chamber to conduct heat transfer measurements under influence of strong electric and/or magnetic fields.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-5

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Apparatus exists but will require modification for operation in zero-g. Some redesign to eliminate high-voltage hazards to astronauts may be required. Must pass space-qualification tests.

   Characteristics include (1) interaction region, 5 inches diameter by 2 inches high; (2) electric field, to 10^6 v/m; and (3) magnetic field, 2,000 gauss (ordinary), 100,000 gauss (superconducting).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This apparatus exists only as a special one-of-a-kind laboratory device intended for use in a 1-g environment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Construct experiment chamber of conventional design with special consideration of zero-g effects and safety hazards.

12. SPECIAL FACILITIES REQUIRED. Large vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Superconducting Magnets

2. BRIEF DESCRIPTION. A study to determine advantages of superconducting magnets relative to conventional magnets for use with physics experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-5, -11, 4-CR-1 through -10

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A study is required to define the benefits and penalties involved in the choice of magnet systems for various physics experiments. This study would assess the relative benefits arising from the reduced power of the superconducting magnet versus the cryogenic logistics requirement; the safety hazards relative to each; the value of integrating the magnet cryogenics demand with other demands (such as the hydrogen target, biology requirements, etc.) and would also investigate the feasibility of using superconducting magnets for other experiments which presently specify only conventional magnets (such as 4-P/C-5 and 4-P/C-11).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Superconducting magnets operate essentially loss-free but require liquid helium, a consumable. Conventional magnets are much simpler but require large amounts of electrical power to generate high field strengths. Spaceborne superconducting magnets are under development.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-20, P-24

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Integrated Physics Apparatus

2. BRIEF DESCRIPTION. Study to determine feasiblity of developing an integrated apparatus package for the Physics/ Chemistry Research Clusters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-1 through 4-P/C-11

4. ITEM NO(S). 3, 6, 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Systems; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The Physics/Chemistry Research Clusters have many common apparatus requirements: ovens, induction heaters, pyrometers, vacuum airlocks, etc. If no operational conflicts exist, a common experiment package may yield weight and cost savings. The relative advantages of an integrated system (common consoles, power supplies, etc.) would have to be compared with disadvantages (scheduling conflicts among different experimenters, loss of reliability, and any other degradations arising from possible integration compromises).

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Almost all the components of the proposed integrated apparatus package exist and require only qualification testing.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This STD item is the key item by which the requirements of the following STD items are integrated: P-1, P-2, P-4, P-7, P-8, P-9, P-10, P-12, P-14, P-16, P-19, P-24, P-25

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A large vacuum chamber.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $750,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Wicking Apparatus

2. BRIEF DESCRIPTION. Development of test apparatus for wicking experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-10

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This apparatus is an assemblage of standard items (bladder tanks, helium bottle, valves, manifold, wick, heater, etc.,) and implies no advancement in the state-of-the-art. The package includes instruments to measure pressure (0 to 20 psia), acceleration (to 10^{-6}g), temperature (50° to 90°F), and heater power (to 50w). Also included are recorders and video cameras for making permanent records. Not included are vibration isolation devices (see P-6 and P-22) and contaminant-control devices (see P-17). Will require in-space qualification testing.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is sufficient.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-22

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Unknown

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. G-Level Control

2. BRIEF DESCRIPTION. Development of a device to provide specified, repeatable low g-levels specifically for the capillary flow apparatus, but also for other physics apparatus with these requirements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-7, -10, -11; (Important) 4-P/C-2, -3, -6

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some means is required for providing repeatable g-levels in three steps (10^{-2}, 10^{-4}, and 10^{-6}g) for the entire wicking test apparatus. These g-levels can be degraded no more than ± 10 percent by outside disturbances and must be maintained for 10 minutes at a time. A study is required to evaluate the feasability of meeting all low-g requirements in space physics with one device.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Large space stations cannot be controlled with this precision. A chamber-within-a-chamber, with or without isolation mounts is a candidate solution. The size of such a chamber will depend upon the desired g-level, the vehicle disturbances and the experiment duration. All of these factors will be considered in the above study.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-6, P-11, P-21

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Unknown

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months (for study). 24 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 (for study). $1 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Heat Transfer Apparatus

2. BRIEF DESCRIPTION. Development of apparatus for use in boiling and convective heat transfer experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-3

4. ITEM NO(S). 6, 7

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The required apparatus consists of a tank suitable for both cryogenic and noncryogenic liquids equipped with viewports, fill, drain, and vent lines, controlled-temperature heaters, and devices to measure pressures and temperatures. A camera will be used for time-motion studies and a low-level accelerometer (see STD No. P-5) will be used to monitor g-level. All requirements are well within the present state-of-the-art except possibly the temperature monitor. Operational procedures must be developed on the ground. Temperature range: 13° to 445°K ± 0.6°K above 60°K, ± 0.01°K below 60°K. Pressure range: 10^{-5} to 760 Torr ± 1 percent.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is adequate except that accommodating this wide temperature range in one instrument may pose problems.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-36, P-37

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATING. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Apparatus for Controlled Density Materials Study.

2. BRIEF DESCRIPTION. Development of apparatus for controlled density materials experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-4

4. ITEM NO(S). 6, 7, 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Apparatus for gas sparging, mixing and shaking is required for production of foams, extrusions, composites, and cast pieces. Materials include molten metals and glasses. Accelerations, temperatures, pressures, and atmospheric composition must be monitored as follows: (1) gas sparger pressure, 0-3,000 psig ± 2 percent; (2) shaker g-level, 0-10g ± 1 percent, (3) ambient g-level, to 10^{-3}g (see P-8); (4) chamber temperature, 20° to 3,500°C; (5) chamber pressure, 10^{-5} to 760 Torr; and (6) atmospheric composition. A study is also required to address the human factors and safety aspects of the high temperatures and pressures.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The above is largely within the present state-of-the-art. The low-g accelerometer has been previously described (see STD No. P-8). Pressure can be measured in two stages by a device similar to the MKS Berration Type 77 Electronic Pressure Meter using interchangeable sensing heads.

Atmospheric composition is measured with a gas chromatograph (see STD No. P-2) and temperature with a standard thermometer or pyrometer (see STD No. P-3).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED.

    P-20, Integrated Physics Apparatus
    P-25, Film-Video Tape Trade Study
    P-11, Melting Apparatus (development only)

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENTS COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months (for study). 24 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 (for study). $2 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Film-Video Tape Trade Study

2. BRIEF DESCRIPTION. Trade study to determine merits of video tape recording relative to movie film.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-1, -2, -3, -7, -9, -10, -11, 4-PP-2-1, -2-2, 1-BM-5, -6, 1-BR-1-1, -1-3, -1-4, -2-1, -2-2, -3, -4, 1-MM-1, -2, -3, -5, 6-G-3, 6-H-2, -4, 6-M-4, -5, 6-O-1

4. ITEM NO(S). 6, 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some physics experiments require several minutes of visual recording, followed by on-site processing (development or playback) and evaluation. Either a video tape recorder or a movie camera would suffice. This STD item relates to finding the optimum recording device.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Neither on-board film processors nor video tape machines are space-qualified at present.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). This STD item should precede STD No. P-26.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTIONS

1. STD TITLE. On-Board Film Processing

2. BRIEF DESCRIPTION. Development of movie film processing system for use with physics experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-1, -2, -3, -7, -9, -11, 4-CR-1 through -10, 4-PP-2-1, -2-2

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some physics experiments require processing of 500 to 2,000 feet of black and white movie film so that the experimenter can evaluate experimental results.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. There are no space-qualified film processors.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Depending upon the results on STD No. P-25, this item will either follow STD No. P-25 or else will be unnecessary. (STD No. 25 assesses the trades between film and video tape for data evaluation.)

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Transition Radiation Detectors

2. BRIEF DESCRIPTION. Development of transition radiation detectors for cosmic ray experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-CR-1 through -10

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities; development.

6. OBJECTIVES. Theory; Components; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. For practical applications, this instrument requires the development of high efficiency, large area, and high spatial resolution X-ray detectors. No further details are available due to the advanced nature of this development.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. When a charged particle crosses a dielectric boundary it emits electromagnetic radiation. The frequency spectrum extends from the optical to the x-ray region. If limited to a small frequency interval ω_p, the total energy in the x-ray region is $\frac{2}{3}\frac{e^2}{c}\omega_p y$, where y is the Lorentz factor, a function only of velocity $\gamma = (1 - v^2/c^2)^{-1/2}$. Transition radiation is theoretically understood but practically unusable at the present time.

E

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This development is one instrument in the Cosmic Ray Experiment Package, STD No. P-15. It is listed separately because of the advanced nature of the required development.

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A high energy accelerator for non-space testing.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A research program is currently underway at Brookhaven National Laboratory.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months (for study and experiments). 12 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million (for study and experiments). $1 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Superconducting Materials

2. BRIEF DESCRIPTION. Research and development program to find superconductors with higher transition temperatures.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-5, -11, 4-CR-1 through -10

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities.

6. OBJECTIVES. Theory; Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The development of practical superconducting alloys, which can be fabricated into coil wire, and which would sustain high critical fields (100 kG) at liquid hydrogen temperatures would decrease the power requirements for the cryogenic system. It would also simplify logistics since the same fluid (liquid hydrogen) would be used both as a fuel and a coolant.

   The problem is primarily one of metallurgy. There is no way to predict the limit on critical temperature and hence critical field.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theory of superconductivity is well known. It is believed that the highest transition temperature one can hope to achieve is about 25° to 30°K.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-19

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. A ground-based laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Various laboratories are investigating these possibilities; notably Bell Labs.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cryogenic Systems

2. BRIEF DESCRIPTION. Study of techniques for operating large cryogenic systems in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-CR-1 through -10, 2-VB-1, -2, -3, 2-IN-1, -2, -3, 2-P/T-1, -2, -3; (Important) 4-P/C-2, -5, -11, 6-A/F-1, -2, -3, -4, -5, 6-G-1, -2, -3, -4, -5, -6, 6-H-1, -3, -4, -5, -6, -7, 6-M-1, -6, 6-0-1, -2, -3, -6

4. ITEM NO(S). 4, 5 of 4-CR-9 Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space and not in space to define present capabilities.

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Detailed design and analysis of the behavior of low temperature liquids in a zero-g environment and the technology required to maintain large volumes at liquid helium temperatures by a closed loop refrigeration system. Another problem may be the development of techniques by which the amount of helium remaining in a Dewar vessel or tank may be gaged.

Transfer and recovery of helium are subjects of study. Study should also address possibilities of using vented helium (or exhaust) as a coolant for other experiments (e.g., space biology).

PROGRAMMATIC ASPECTS

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Problems related to storage and transfer in space of every large cryogenic supplies are unknown, except for the work by the National Bureau of Standards, Beech Aircraft, and Ball Brothers. Ground storage and transfer present no unique problems.

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Space and ground-based laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Any laboratory or space programs where large cryogenic systems or superconducting magnets are being investigated.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months (both study and experiments integrated into one program).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Plasma Physics Subsatellites

2. BRIEF DESCRIPTION. Development of a subsatellite which meets all requirements of the plasma physics experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PP-1, -2-1, -2-2, -2-3, -3-3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The following subsatellite requirements arise from the plasma physics experiments: (1) a vehicle for mapping the wake of the space station; contains Langmuir probes, electric field meters, alfven wave detectors, magnetometers, telemetry, etc.; (2) a vehicle to release barium cannisters at distances of about 15 km from the space station; contains magnetometer and telemetry; and (3) a vehicle to take TV pictures of artificial auroras.

   All subsatellites are unmanned but controlled from the space station. A study should be done to determine the optimum number of subsatellites for each experiment and their most effective placement. The possibility of having a single design concept to satisfy all requirements should be investigated.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Within the state-of-the-art, but design study is a necessary precursor to these experiments.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-33

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Unknown

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (for study). 36 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million (for study). $10 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. DC Electric Field Measurement

2. BRIEF DESCRIPTION. Study to determine best way of measuring the dc electric field in the vicinity of a space vehicle.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PP-1

4. ITEM NO(S). No. 3 of Attachment to Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities; development

6. OBJECTIVES. Theory; Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A device is required which is capable of measuring dc electric fields as low as 1 mv/m. (The field strength at the Earth's surface varies from 65 to 317 v/m.) Although a direct measurement is desired, a means of inferring the field strength from other measurements is acceptable. Contact potentials and $\vec{v}$-cross-$\vec{B}$ effects must be nulled out.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Little is known about the coupling between a dc electric field probe and the plasma near a vehicle. The problem requires much further study.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-3, P-32, P-34, P-35

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months (for study and experiments). 12 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million (for study and experiments). $1 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Plasma Diagnostic Techniques

2. BRIEF DESCRIPTION. Comparison of alkali cloud technique with marshall gun technique for plasma diagnosis.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PP-2-1, -2-2, -2-3

4. ITEM NO(S). Question No. 3 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A study is required to determine which procedure - release of alkali clouds or injection of dense plasmas - is better for use with the diagnostic experiments proposed in this group.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Barium clouds have been studied via sounding rockets and the alkali cloud technique is the preferred method. High power plasma injectors (Marshall gun) have not been flown in space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-31, P-34, P-35

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Barium Cloud Apparatus

2. BRIEF DESCRIPTION. Development of space-qualified equipment for alkali-metal clouds experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PP-2-1

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The following instruments are required for measuring magnetic flux density out to synchronous altitudes; (1) three-axis flux gate magnetometer for measuring magnetic flux density out to synchronous altitudes; (2) photometer, 45^{o} fov, 4554A to 4934A, 50A bandwidths; (3) scanning photometer, f1.5, ~1^{o} detection area, ~30 sec scan rate, ±0.1^{o} angle accuracy, same bands as photometer; (4) 5-inch format camera with mount, zoom lens and filter wheel, with filters for BaI, BaII, and StI emission lines; (5) vidicon with adjustable filters; (6) swept Langmuir probe, 2 cm diameter with sweep generators, tuned amplifiers, and telemetry; and (7) steerable barium release canister to accommodate the above instruments.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. All but Items 2 and 5 of the previous list are space-qualified; others require both development and qualification. More complete details are given in Part V of the 4-PP-2-1 group description.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-30

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Space simulation laboratories.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 30 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Intense Electron Sources

2. BRIEF DESCRIPTION. Development of intense high power electron beam sources.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-PP-2-2

4. ITEM NO(S). 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space to define present capabilities; development.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A stludy is required to clearly specify the energy, intensity (amperes), beam size, and operational characteristics (e.g., charge neutralization) of high power electron beam sources for use as space plasma diagnostic tools. The expected energy level and intensity is, respectively, >10 kev and >1 ampere. In-space measurements of path attenuation also must be made.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. More theoretical work on beam/plasma interactions will be helpful. Beams of 4.5 kw power levels have been flown (9 kev and 1/2 ampere).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-31, P-32, P-34.

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (for study and experiments). 12 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$500,000 (for study and experiments). \$5 Million (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Research in Plasma Physics

2. BRIEF DESCRIPTION. Research programs in plasma physics theory which will be complemented by Earth orbital experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-PP-1, 4-PP-2-1, -2-2, -2-3, 4-PP-3-3; (Important) 4-P/C-11

4. ITEM NO(S). 2, 4, and Synopses

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theoretical research programs are required to satisfy deficiencies in existing plasma theories and to modify theories with results obtained from the experimental program. Theoretical areas to be considered are: (1) Alfven waves, existence and detection; (2) nonlinear coupling phenomena; (3) electron/plasma interactions; (4) plasma resonances; and (5) wake physics.

   The programs should be conducted in parallel with the experiment program so that interaction from one program to another can proceed in a timely manner. Ground-based experiment programs are also required in laboratory simulation of wakes and wake/interactions, and studies of quiescent plasmas.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The above studies are presently underway in various government, industry, and university laboratories, but would benefit from a centralized coordination so that their results would contribute more directly to the requirements of the Plasma Physics Research Clusters.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-31, P-32, P-34.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Organize a plasma physics clearinghouse to gather, collate, and disseminate theoretical and experimental data.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Many in various university and government laboratories.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 5 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Apparatus for Superfluid Tests

2. BRIEF DESCRIPTION. Development of test apparatus for experiments in superfluidity.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-11

4. ITEM NO(S). 51

TYPE STD EFFORT

5. ACTIVITIES. Study; development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The apparatus required here is very similar to that required for Group 4-PC-3. One device could probably suffice for both. Requirements are: (1) a Dewar-vessel with viewports (See STD No. P-37); (2) thermocouples for 1° to 2°K range, $\pm 0.01^{\circ}$K; (3) reticles for spatial measurements, +0.01 cm; (4) remote handling device (See STD No. P-38); and (5) fountain momentum measuring device. Entire apparatus must be subjected to known g-levels of 10^{-2}, 10^{-4}, and 10^{-6}g, ±1 percent (See STD No. P-22). Provision must be made for photometric observations. Study is required to design momentum measuring device. This device is required because in zero-g the fountain will not fall back. Hence, height cannot be measured, but must be calculated.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Except for the indicated STD items and the fountain momentum measuring device, the other items (thermocouples, reticles, etc.) are within the state-of-the-art.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-23, P-37, P-38

11. SUGGESTED DEVELOPMENT APPROACH(ES). A spring- or magnetically-loaded plate coupled to a transducer may suffice for the momentum measuring device.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (for study). 24 Months (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 (for study). * $2 Million (for development). *

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

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*Estimates refer only to Items No. 2, 3, and 5 of Question No. 7 plus the associated tanks and plumbing.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Dewar Viewport Studies

2. BRIEF DESCRIPTION. Study to determine best viewport design for Dewars used in physics experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (CRITICAL) 4-P/C-3, -11; (Important) 4-P/C-2

4. ITEM NO(S). 52

TYPE OF STD EFFORT

5. ACTIVITIES. Study, development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Liquid helium is very difficult to keep in a Dewar-vessel with even the slightest heat loss. A window casually formed in a Dewar would cause so much helium loss as to be unacceptable. Vacuum or liquid nitrogen shielding with prism or fibre-optic light paths are possible solutions. Placement of the Dewar outside the spacecraft and orientation toward dark space might also be considered. A study is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Windows have been cut into liquid helium Dewars for qualitative observation. Since the view is through a liquid nitrogen jacket, errors due to diffraction arise. An optically correct view is required for this application.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-23, P-36, P-38

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months (for study).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000 (for study).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cryogenic Remote Handling

2. BRIEF DESCRIPTION. Studies and experiments related to remote handling of test objects at cryogenic temperature.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 4-P/C-11; (Important) 4-P/C-2, -3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Extension of remote handling mechanical arms into zero g environment at cryogenic temperatures. The apparatus of 4-P/C-11 (creeping film device and fountain effect apparatus) must be physically positioned by the remote arms.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Remote handling mechanical arms fully operational under normal gravity conditions.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. P-36, P-37

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months (assumes study and experiments are integrated).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Superfluid Research

2. BRIEF DESCRIPTION. Research into behavior of superfluids with emphasis on understanding the fountain effect and the creeping film effect.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 4-P/C-11

4. ITEM NO(S).

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Extend existing theories on fountain effect to include gravity dependence. Develop new theory for creeping film effect, including gravity dependence. Coordinate both efforts with experimental activities so that results may be compared. See 4-P/C-11 for complete discussion of these effects.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Feinman/ Landau two-fluid theory explains fountain effect at 1-g. No present theory can explain creeping film effect.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. 94GHz Amplitude and Phase Measurement System

2. BRIEF DESCRIPTION. Development of microwave system to automatically measure amplitude and phase at 94 GHz.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-1

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Measurement of amplitude over a 20 dB dynamic range and relative phase of ± 180° range; accuracies of 0.2 dB and 2°, respectively; operating frequency, 94 GHz.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Rantec Corp markets automatic amplitude and phase measuring systems which meet the above requirements except for operating frequency which is limited to 18 GHz. Extension to 35 GHz seems straightforward; but 94 GHz operation remains an STD item.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-3, C-4, C-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Unknown

13. KNOWN ONGOING ACTIVITIES. WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. MM Waves Experiment Plan

2. BRIEF DESCRIPTION. Study to design MM waves experiment and plan coordination between satellites, ground stations, and weather stations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-1

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A study is required to perform the following: (1) design the MM Waves Experiment; (2) set-up procedures for coordinating these activities with weather stations on the ground; (3) specify which ground stations will be used for transmission and reception; (4) organize data flow from astronaut/scientist to user and specify where and what data processing is required. Coordination with weather stations must be on a real-time basis in order to take advantage of opportunistic testing. World-wide synoptic records will also be required for post-experiment analysis.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is sufficient.

G

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEM WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-4, C-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. MM Wave Experiment Package

2. BRIEF DESCRIPTION. Development of complete experiment package for MM waves demonstration.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-1

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. With the exception of STD Items C-1, -2, -4, and -5, this experiment package consists of state-of-the-art subsystems (receivers, tracking filters, code generators, etc.) which require only qualification testing. The detailed descriptions are too lengthy to repeat here, but given in items 49 through 54 of Group 5-CS-1. The "development" requirement refers to the integration of these subsystems into a workable system.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is adequate.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-1, C-4, C-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Electronics qualification-test facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Broadband Modulators

2. BRIEF DESCRIPTION. Study of broadband modulators for handling Gigahertz data rates at 35 and 94 GHz carrier frequencies.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-1

4. ITEM NO(S). Part 5 of Attachment 1

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Data rates up to 1 GHz are to be evaluated in this experiment group at two carrier frequencies: 35 and 94 GHz. A study is required to define the type of modulation used (such as PCM or PSK) followed by development of the modulators for each band.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. ATS-E will use a 50 MHz bandwidth at 35 GHz. BTL has developed a 224 Megabit PCM terminal. Very little equipment is available in the 94 GHz band.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-1, C-2, C-3, C-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. ATS-E

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months Study; 24 Months Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 Study; $5 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. High-Speed Correlator

2. BRIEF DESCRIPTION. Development of a high-speed real-time amplitude and phase correlator.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-1

4. ITEM NO(S). Question 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. High speed correlators are necessary to perform real time analyses on complex signal spectra. These analyses will include both auto-correlation techniques and cross-correlation with locally generated spectra. Initially, a theoretical study must be made to understand what techniques can be used, how they can be implemented, and how the data from the correlators can be processed and interpreted. Techniques must be developed to process high speed signals without requiring excessive output data bandwidths. The output data must be of a character such that it can be related to communication system parameters, such as bit error rate, signal-to-noise ratios, envelope time delay and harmonic and nonharmonic signal distortion. Proper utilization of this technique can lead to complete characterization of the propagating medium independent of the experimental instrumentation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The basic theory is currently well understood. However, the optimum way to apply the theory to the processing of wideband PM signals has not been determined. The present state-of-the-art in correlators is presently represented in instruments such as the Hewlett Packard Model 3721A. This instrument is currently limited to an input bandwidth of 250 KHz and to 900 delay offsets.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-1, C-2, C-3, C-4

11. SUGGESTED DEVELOPMENT APPROACH(ES). Develop the necessary theory for the data handling first, then develop necessary instrumentation.

12. SPECIAL FACILITIES REQUIRED. A laboratory high speed digital PM modem is required to study the problem thoroughly. Thus, in a non-space environment, the data handling and processing interfaces can be properly investigated.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Various TRW Systems IR&D activities, including the 400 Mb/sec high speed digital modem.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months for Study; 18 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $700,000 for a working breadboard system. Estimate based on the cost of the TRW wideband digital efforts, plus an estimation of the manpower involved; $100,000 for initial study.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Laser Telescope Alignment

2. BRIEF DESCRIPTION. Improved long-term optical alignment of laser telescopes.

SOURCE FROM WHICH THIS STD REQUIREMENTS IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-2

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; development; experiments in space to define present capabilities

6. OBJECTIVES. Component; system

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The optical axis of the transmitting and receiving equipment must be kept in proper alignment and thermal expansion of the supporting structure, including surface distortion of optics, must be controlled or compensated to maintain precise focus. Composite low expansion materials (i. e., Pyroceram and Cervit) exhibit coefficients below $10^{-7}/°C$. The reduction of thermal effects to correct focus and control axis alignment is fundamental to operational laser systems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A 4°C difference between sides of a 1-meter mirror of fused quartz, normal to the axis, would be intolerable for maintaining focus. In addition, a temperature difference between front and back surfaces of the mirror cannot exceed 0.1°C without unacceptable distortion. Low orbiting experiments (below 800 km) using large diffraction limited optics would suffer from these thermal effects due to earth shine. Techniques of mirror construction using materials having small coefficient of expansion, specific heat, and larger thermal conductivity must be investigated. Metal, fused silica and vitreous ceramics are leading candidates.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-30

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Space Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
24 Months for Integrated Studies and Space Experiments;
60 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$4 Million for Studies and Space Experiments;
$6 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Improved Satellite Tracking

2. BRIEF DESCRIPTION. Improve accuracy of satellite tracking.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -3

4. ITEM NO(S). 10

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Error evaluation experiment to verify satellite use for terrestrial navigation accuracy to ±10 meters requires relatively precise knowledge of the satellite positions and velocities. In view of the NASA planning to reduce the ground tracking network operating cost by closing down tracking stations in the late 1970's, techniques to improve the tracking accuracies from few ground stations with limited tracking coverage must be developed. Current forecast for accuracy without closeout of any ground stations is ±150 meters for low Earth orbit. Improvements in tracking equipment and software are required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. With the current NASA tracking network (e.g. MSFN), the accuracy is ±150 meters overall. Plans exist to close down some of these ground stations in the near future.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD C-14; STD C-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Develop improved data processing techniques for smoothing and predicting satellite orbit parameters or retain continuous full operational capabilities of ground tracking stations.

12. SPECIAL FACILITIES REQUIRED. NASA tracking network, computational facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 Study; $2 Million Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Subsatellite for Navigation

2. BRIEF DESCRIPTION. Development of subsatellite for navigation experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 5-NS-1; (Important) 5-NS-4

4. ITEM NO. Question 4 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Subsatellites are to be operated from the Space Station. These are automated satellites which will contain self propelling and attitude control capabilities with command receivers and transponders to be controlled and tracked by the Space Station.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Capability exists; particular design must be configured and developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD C-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Develop as carriers for equipments for surveillance system (5-NS-4) and this experiment.

12. SPECIAL FACILITIES REQUIRED. Spacecraft manufacturer with research and test capabilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA Space Station study experiment definitions on free-flying experiments and subsatellites.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$10 Million, based on development cost of subsatellites by MMC in Space Station ϕB Study.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Transponders

2. BRIEF DESCRIPTION. Develop transponders for navigation satellites.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -4

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Space qualified transponder system consisting of transmitters, receivers, and antennas are required. If the Space Station is used as the master station in the navigation system, a master clock, signal generators, modulators, and additional transmitters are required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Technology and operational capabilities exist; specific design for this application needs to be developed and qualified.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-17, C-20

C 2

11. SUGGESTED DEVELOPMENT APPROACH(ES). Design approach similar to that for Surveillance System experiment (5-NS-4) may be utilized.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Several navigation satellite programs and proposals, such as Nav. Star.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Data Processing Software

2. BRIEF DESCRIPTION. Development of software techniques for data processing.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 5-NS-1; (Important) 5-NS-4

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Computer programs are needed to evaluate recorded data and provide such material as error estimates, system performance, correlation of experimental results, and correlation of theoretical values and test results. All computation will be ground based at a central location.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory involved is well defined. However, computer programs of this type and magnitude have not received a great deal of attention. The operational aspects of loading the many forms of data into the computer requires further study.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEM WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-18, C-21

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground based computer facilities currently in use are adequate.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA Space Station Study might provide useful information.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 24 Months for Development.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 for Study; $750,000 for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Satellite Position Determination

2. BRIEF DESCRIPTION. Satellite position determination by tracking from ground or space station.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -3, -4

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Satellite position can be determined by ground tracking. However, the cost of ground tracking may be prohibitive. A trade study, utilizing as criteria such items as cost, accuracy, and impact on Space Station, would indicate the feasibility of determining satellite position from the Space Station.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Trade studies of this type are not difficult. The definition of accurate trade criteria presents the greatest problem.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-7 and C-14

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Develop Laser Radar

2. BRIEF DESCRIPTION. Development of space-qualified laser radar equipments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-2

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Space-qualified laser radar, radar targets and computation capabilities to be integrated with Space Shuttle and Space Station avionics.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Prototype designs of laser radars and targets exist; integration concepts and software are in development.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Perfect and qualify pulse radar in development by ITT. Perfect and qualify CW radar, such as ITT and MDAC.

12. SPECIAL FACILITIES REQUIRED. R&D and environment test facility for laser instrument manufacturer.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA/MSFC contract with ITT on Laser Docking sensor development.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million for Pulse Radar

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Autonomous Navigation Sensors

2. BRIEF DESCRIPTION. Develop autonomous navigation sensors for space vehicles (landmark trackers, altimeters, sextants).

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-3

4. ITEM NO. Question 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Space-qualified sensors for autonomous navigation are required to configure several navigation schemes and for sensor performance evaluation. Among these are advanced units of star trackers, sextants, radars, receivers, IMU's, horizon sensors, and planet sensors. In addition, landmark trackers and laser devices must be developed to be space flight qualified.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Autonomous navigation sensors for space vehicles have been studied and their designs have been conceived and in many cases developed. However, sensors such as the landmark tracker, laser altimeter, etc., have not yet been designed for space flight application; breadboard units exist in most cases. Flight qualifiable designs must be developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Continue current developments, participate in DOD development of applicable sensors, or initiate separate developments.

12. SPECIAL FACILITIES REQUIRED. Sensor manufacturers with R&D capability.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years for landmark tracker space application qualification. Laser altimeter development three years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million Landmark Tracker; $2 Million Laser Altimeter

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Improved Position Determination

2. BRIEF DESCRIPTION. Improve Space Station Position Determination

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The autonomous navigation measurement accuracies (classified in some cases) required in this experiment will require precision determination of the Space Station orbital position for performance verification. An order of magnitude improvement in ground tracking capability or satellite navigation schemes may be required for these experiments.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current NASA tracking station network capability provides ±150 meters overall for low Earth orbits. Improvements will depend on the accuracy goals of autonomous navigation schemes to be investigated.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-7 and C-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Improve or maintain current tracking capabilities using ground stations, navigation satellites or combination of both. Combine with 5-NS-1 effort.

12. SPECIAL FACILITIES REQUIRED. NASA tracking network, navigation satellite system, computational facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Tracking and Data Relay Satellite (TDRS) System and Data Relay Satellite System (DRSS) studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 for Study; $2 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Software Development

2. BRIEF DESCRIPTION. Software for autonomous orbital navigation.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Software required for autonomous orbital navigation has never been adequately defined for systems other than two star trackers and a landmark tracker. Filtering techniques need to be defined and integrated into an overall approach for the various systems. Start-up techniques require further definition.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Research and development contracts have devoted considerable effort to landmark trackers, star trackers, and gyros working in conjunction.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Computing capability on Space Station.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Space Station studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months for Study; 18 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 for Study; $2 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Subsatellites for Surveillance

2. BRIEF DESCRIPTION. Development of Subsatellites for Surveillance System

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 5-NS-1, -4; (Important) 1-MM-1

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Subsatellites are to be deployed and controlled from the Space Station. These are similar to those used for 5-NS-1 and may be designed as part of 5-NS-1 subsatellite.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Capability exists; particular design must be configured and developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-8

11. SUGGESTED DEVELOPMENT APPROACH(ES). Develop as carriers for equipments for terrestrial navigation (5-NS-1) and this experiment.

12. SPECIAL FACILITIES REQUIRED. Spacecraft manufacturer with research and test facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA Space Station study experiment definitions on free flying experiments and subsatellites.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10 Million; based on estimated development cost of subsatellite by MMC in Space Station Phase B study.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Transponders

2. BRIEF DESCRIPTION. Develop RF transponders for surveillance system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -4

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Space-qualified transponder system consisting of antennas, diplexers, receivers, frequency translators and transmitters is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Technology and operational capabilities exist; specific design for this application needs to be developed and qualified.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-9; C-20

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. COMSAT proposal on similar application of satellites.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Traffic Control Computer Software

2. BRIEF DESCRIPTION. Development of software techniques for data processing required for ship and aircraft traffic control.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -4

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Ships and aircraft position and velocity are transmitted to a traffic controller for processing to develop control commands for individual users. Computer programs which process the basic data to develop control commands must be developed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A large realtime simulation will be required to process the user data. The technology exists, however a program may evolve which exceeds current computer capability.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-10; C-21

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Large ground-based computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. COMSAT Corp. proposal to provide UHF and VHF services for navigation and surveillance tests.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250, 000 for Study; $1 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Collision Avoidance Hardware

2. BRIEF DESCRIPTION. Design and develop clock signal test transmitter and compatible ground receiving equipment.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-5

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Detailed statistics of propagation errors versus latitude and time for frequencies available to mobile navigation services. Develop practical matched filter detectors for time or ranging reception with emphasis on cost reduction.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Matched filters are available for FM (chirp) radar. PN ranging has been developed for many applications. Comparison of propagation errors has been done for doppler nav signals (phase velocity variance). Satellite position location is presently performed at S-band with PN techniques. Precise ranging is obtained by extensive computer processing.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Trade-off studies required.

12. SPECIAL FACILITIES REQUIRED. Could be done by a number of R&D concerns with manufacturing capability.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months for Study; 18 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 for Study; $1 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Emergency Location Signal Detectors

2. BRIEF DESCRIPTION. Development of onboard detector for emergency location transmitter signals.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-1, -6

4. ITEM NO. Question 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Space-qualified emergency location transmission detector including antennas, receivers and processors for location determination is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Concept exists; space-qualified equipment needs to be developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-9; C-17

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Communication system development facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million for antennas, receiver and preprocessor; use space station experiment computer for onboard data processing.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Software Development

2. BRIEF DESCRIPTION. Software development for location methods.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-NS-6

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES; Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Software development is required for the various location methods which include, ranging, doppler shift, or angle measured from satellite. These developments include filtering techniques and computer programs to implement the techniques and provide the necessary data processing.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory is well understood but needs application to the problem at hand.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-10; C-18

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 12 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 for Study; $750,000 for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Low Noise Receivers

2. BRIEF DESCRIPTION. Development of lower noise figure receivers at frequencies between 20 and 100 GHz.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-N-1

4. ITEM NO(S). 53

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Measurement of noise over a range of 50 to 3×10^5 °K in the frequency band from 100 MHz to 100 GHz. Measurement accuracies of ±2 db in an instantaneous dynamic range of 55 db.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The noise figure of RF front ends depends on the type of device utilized. The current state of the art for frequencies between 10 and 100 GHz are: (1) Mixer (10 db to 20 db); (2) traveling wave Maser (0.3 to 2 db); (3) uncooled parametric amplifier (3 to 12 db) upper frequency limit at approximately 40 GHz. The use of the traveling wave Maser would require a cryogenic system, which does not seem practical. It has been predicted that uncooled parametric amplifiers will be developed that have 5 db noise figures at 100 GHz and mixers will exhibit 7 db noise figures at 100 GHz.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Limit upper frequency to 18 GHz with possible extension up to 35 GHz.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None known

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months for Study; 30 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500, 000 for Study; $5 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

C

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Computer Software

2. BRIEF DESCRIPTION. Development of computer software for noise measurements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-N-1

4. ITEM NO. Question 5 of Synopsis

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Data compression algorithms for various frequency noise measurements will require understanding of what decision making information will be supplied to crew. Hard copy requirements are important as they have greatest hardware impact. Digitized photo techniques/hardware and software need more development for type of information contemplated.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Interactive graphics will allow most useful information to be displayed. Most hardware and software should be developed by the time the Space Station flies.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-24

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study of what decision making data is needed and use laboratory to develop good presentation of data.

12. SPECIAL FACILITIES REQUIRED. Interactive graphics facility to determine display characteristics.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Algorithms probably unique, quick look data capability common to any alpha/numeric information required for presentation to crew.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 for Study; $1 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Noise Source Identification Experiment Plan

2. BRIEF DESCRIPTION. Study to define noise source identification experiment and plan coordination with ground stations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-N-2

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. System; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A study is required to: (1) Define noise source identification experiment; (2) Specify which ground stations will be utilized; (3) Set up procedures for coordinating with ground emitters.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present technology is sufficient for carrying out the study.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-23

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Digital Ionosounder

2. BRIEF DESCRIPTION. Development and qualification of digital ionosounder.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-P-1

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This experiment requires transmissions in the 100 KHz to 15 MHz and reception capability in the 50 Hz to 15 MHz frequency bands with frequency accuracies of ±1%. Measurement of time delay between transmitted and received pulses with an accuracy of ±0.5 percent.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This experiment should not require any extensive development effort with regard to the RF transmission and receiving system or measurement equipment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 5-P-2

11. SUGGESTED DEVELOPMENT APPROACH(ES). Incorporate cooperative or non-cooperative radar systems on subsatellite. Utilize RF frequencies above bands of interest for comparison of propagation affects at higher frequencies than those indicated in this experiment.

12. SPECIAL FACILITIES REQUIRED. Antenna system timing equipment.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. The Alouette and ISIS satellite program results should be utilized to determine frequencies and spatial anomaly locations of special interest.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

STD ITEM
NO. C-26

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Higher Efficiency RF Transmitters

2. BRIEF DESCRIPTION. Development of higher efficiency RF transmitters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-P-3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This experiment requires a transmitter capable of providing RF power outputs up to 10 kilowatts at yet undefined frequencies and measurement of the output power to within ±1 db.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. RF power devices such as amplitions, klystrons, traveling wave tubes (TWT's) are capable of producing 10 kilowatts of RF power, but the efficiency of the devices falls off rapidly as a function of frequency. For frequencies above 10 GHz the TWT and klystron appear to be the best candidate at this time. Increased efficiency will reduce the prime power and cooling requirements. Efficiencies in the order of 35% are reasonable at this time. Efficiencies of 60% for klystrons at 10 GHz and 50% for TWT's have been predicted.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-27

11. SUGGESTED DEVELOPMENT APPROACH(ES). Limit power output to 100 watts RF and upper frequency limit to 20 GHz, with possible extension to 35 GHz.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. NASA tracking and data relax satellite (TDRS) and ATS programs.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 9 Months for Study; 36 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 for Study; $5 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. High Power RF Transmitters

2. BRIEF DESCRIPTION. Development of high power RF transmitters

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-P-3

4. ITEM NO(S). 6

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This experiment requires a transmitter capable of providing RF power outputs up to 10 kilowatts and measurement of the output power to within ±1 db.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Currently 20-watt TWT's at X-Band are being flown on TACSAT. Lower power transmitters (less than 1 watt) at 35 GHz have also flown on ATS-5. It is understood that Watkins-Johnson is in the process of space qualifying a 100-watt TWT.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-26

11. SUGGESTED DEVELOPMENT APPROACH(ES). Limit power output to 100 watts RF with possible extension to 1000 watts and upper frequency limit to 20 GHz, with possible extension to 35 GHz.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. NASA Tracking and Data Relay Satellite (TDRS) and ATS programs. NASA has recently released an RFP for the development and qualification of a 100-watt power amplifier at C-Band.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

STD ITEM
NO. C-28

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Software Development

2. BRIEF DESCRIPTION. Development of computer software for propagation experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-P-4

4. ITEM NO(S). 48

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The software required will be utilized to correlate the results of the multipath experiments with type of terrain, time, atmospheric conditions, angle of arrival in order to develop error correction models for navigation, and traffic control systems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Software development looks straightforward and should not require any techniques that have not been developed for other programs.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. 5-P-2

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Ground computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. "Multipath/Modulation Techniques Study - Adaptive Technique Studies," NASA Contract No. NAS5-10749 and "Multipath/Modulation Study for the TDRS," NASA Contract No. NAS5-10744.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Self-Steering Phased Array Antenna

2. BRIEF DESCRIPTION. Development and test of an airborne self-steering phased array antenna system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-P-4

4. ITEM NO(S). 53

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development; Experiments not in space to define present capabilities

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Measurement of relative signal strength between direct and reflected signals in an aircraft over a dynamic range of 40 decibels. The gain of the receiving antenna system is a function of frequency and angle of arrival. In order to obtain meaningful signal strength comparisons the gain variations of the antenna patterns must be well known.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The theory of self-steering phased array antenna system is well understood. Development should be straightforward if upper frequency is limited to X-Band or lower K_u-Band

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). None

12. SPECIAL FACILITIES REQUIRED. Antenna radiation test facility which is available within MDAC-West.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study and Experiments; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $250,000 for Study and Experiments; $1 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Optical Communications System

2. BRIEF DESCRIPTION. Development of space-qualified optical communications system for atmospheric transmission measurements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 5-CS-2

4. ITEM NO(S). 49

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. Component; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Purpose of this effort is to provide experimental data on atmospheric transmission including determination at several laser frequencies of atmospheric absorption, scattering, refraction, noise, and fluctuations in the above due to diurnal, meteorological and turbulent effects, and atmospheric degradation of spatial and temporal coherence. Measurement and understanding of each of the above is critical or important to various phases of laser communications systems development.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Present knowledge and predictability of atmospheric transmittance is severely restricted by lack of data on molecular absorption, chemical kinetic transition probabilities, upper atmospheric meteorology (i.e., humidity, turbulence), atmospheric contamination, etc., and also by a lack of satisfactory methods of calculation for turbulent refraction.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. C-6

11. SUGGESTED DEVELOPMENT APPROACH(ES). Utilize a high-flying aircraft to determine atmospheric effects for wavelengths between 0.3 and 10.6 microns; use most promising wavelengths for space experiment.

12. SPECIAL FACILITIES REQUIRED. Compatible ground optical receiving and transmitting systems and other equipment for analysis of transmissions.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Studies and experiments at 1.06 and 0.53 microns have been conducted at MDAC-ED. Refer to report H036 dated March 14, 1969. ITT has a funded contract to develop an aircraft-to-ground optical communications link utilizing a He-Ne Laser for the downlink and an Argon Laser for the uplink. The atmospheric effects on signal quality of a 30 mbps digital television and PRN ranging code will be evaluated.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months for Study; 24 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million for Study; $10 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Vegetation Species Signature

2. BRIEF DESCRIPTION. Signatures and computer identification of vegetation species.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, 6-A/F-3

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Relationship between optical properties, such as reflectance and emittance, and physical properties, such as leaf shape, temperature, time of day, species and condition of vegetation, trees and low cover, and soil type and quality, the planting season, harvest season, planting pattern and associated artifacts that are unique to certain cultivated species. Sufficient experimental data to prove out existing computer models for automated pattern recognition and to develop new models.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current capacity is the recognition of agricultural crops and the determination of their condition in realtime from a aerial observations using spectral matching, photo interpretive techniques and/or automatic pattern recognition techniques, as illustrated in Figures 1 and 2. The results of the aircraft experiments should be replicated from space to determine if the surface and atmosphere environmental effects are the same for airplane and satellite

platforms. With current USDA operational capability the agricultural user is concerned with statistical estimation rather than total measurement.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EF-2, EF-3, EG-3.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Sensors that operate in the same spectral bands as those used by USDA/NASA programs should be developed and used to replicate the results of ground and aircraft experiments, including computer processing.

12. SPECIAL FACILITIES REQUIRED. Truth sites containing controlled plantings of various vegetation species and means for closely monitoring the surface and atmosphere environment. Computer and species recognition computer programs must be available

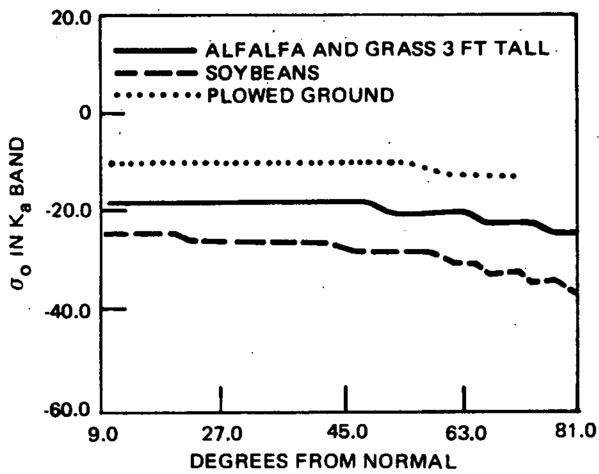
13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The Department of Agriculture and NASA have conducted a number of cooperative research programs with the organizations shown in Figure 3. The LARS organization (circa 1966) is shown in detail as typical of how these programs are organized.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

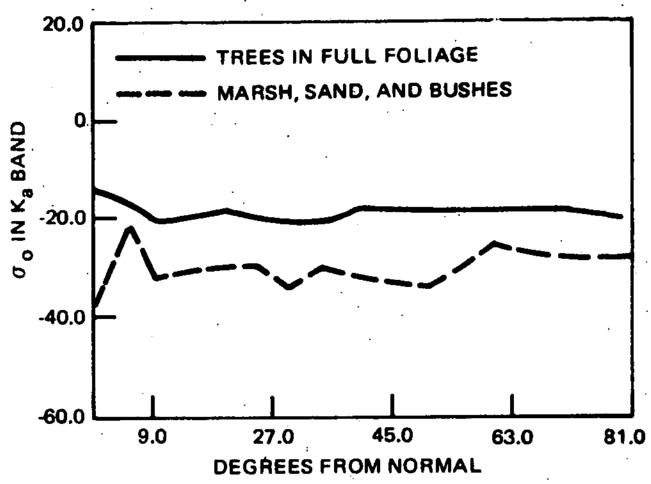
15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 per year as follows:

	Year 1	Year 2	Year 3
Planning & Analysis	$250,000	$200,000	$150,000
Equipment	100,000	50,000	50,000
Ground Test Operations	100,000	50,000	50,000
Aircraft Test Operations	50,000	100,000	50,000
Space Test Operations	0	100,000	200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High



a. RADAR CROSS SECTION OF AGRICULTURAL AREA*



b. RADAR CROSS SECTION OF TREES AND SWAMP*

*FROM R.L. COSGRIFF, W.H. PEAKE, AND R.C. TAYLOR. "TERRAIN SCATTERING PROPERTIES FOR SENSOR SYSTEM DESIGN," TERRAIN HANDBOOK III, ENGINEERING EXPERIMENT STATION BULLETIN NO. 181, THE OHIO STATE UNIVERSITY ANTENNA LABORATORY, MAY 1960

Figure 1. Radar Cross Section of Vegetation and Soil

Figure 1 illustrates that soil is a fairly diffuse radar reflector with low reflectivity. Vegetation is a better reflector. The vertical geometry of the vegetation and its water content are the principle explanation for the increased reflectance (σ_o). The broader-leafed plants, such as soybean and sugar beets, contain more water and their geometry is more favorable than that of the grasses. The upper figure shows soybeans with higher cross sections than grass. A mixture of sand, bushes. and water - in short a swamp - should, to a first approximation, be a mixture of the reflectances of water, soil, and vegetation. Figure 1a shows this to be the case. The radar reflectance of trees is higher than that of the swamp but lower than that of the tilled vegetative types.

Figure from R. L. Cosgriff, W. H. Peake, and R. C. Taylor. "Terrain Scattering Properties for Sensor System Design (Terrain Handbook III)," Engineering Experiment Station Bulletin NO. 181, The Ohio State University Antenna Laboratory, May 1960.

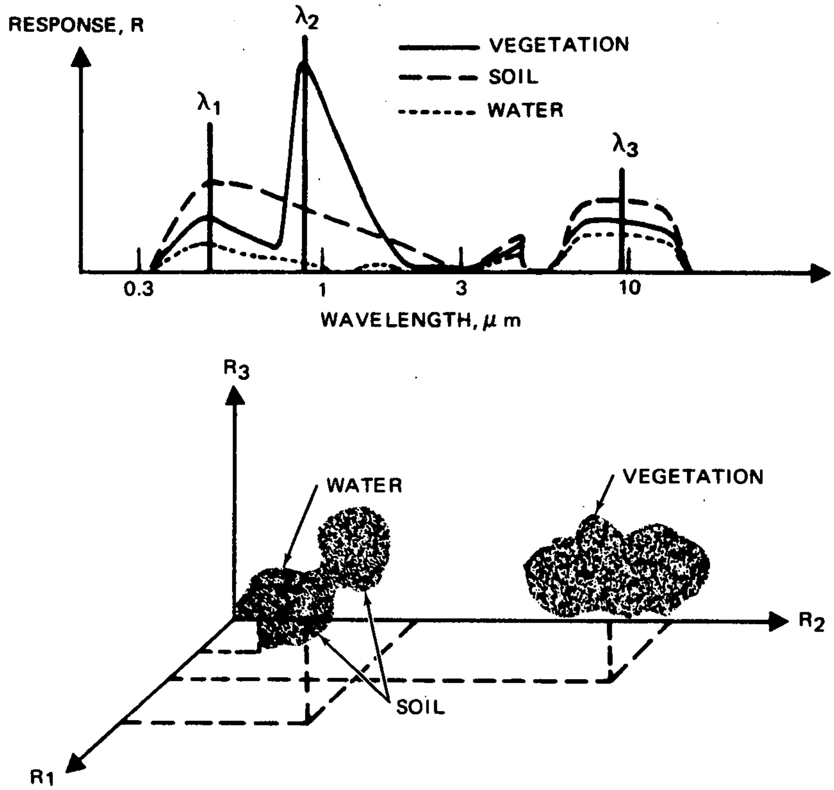


Figure 2. A Three-Dimensional Representation of Response Curves for Vegetation, Soil and Water

The measured response from an object in each spectral band represents the components of an n-dimensional vector. If three bands are chosen, the response from an object in each of the three bands can be plotted in three-dimensional space (R_1, R_2, and R_3), as above. The natural variations of responses for a series of measurements of the object cause the points to form a cluster whose mean position in the three-dimensional space differs enough for the object to be identified. To differentiate species of crops, as many as ten spectral bands may be required. (From R. A. Holmes, "An Agricultural Remote Sensing Information System," EASCON 1968, Conference Record, p. 148.)

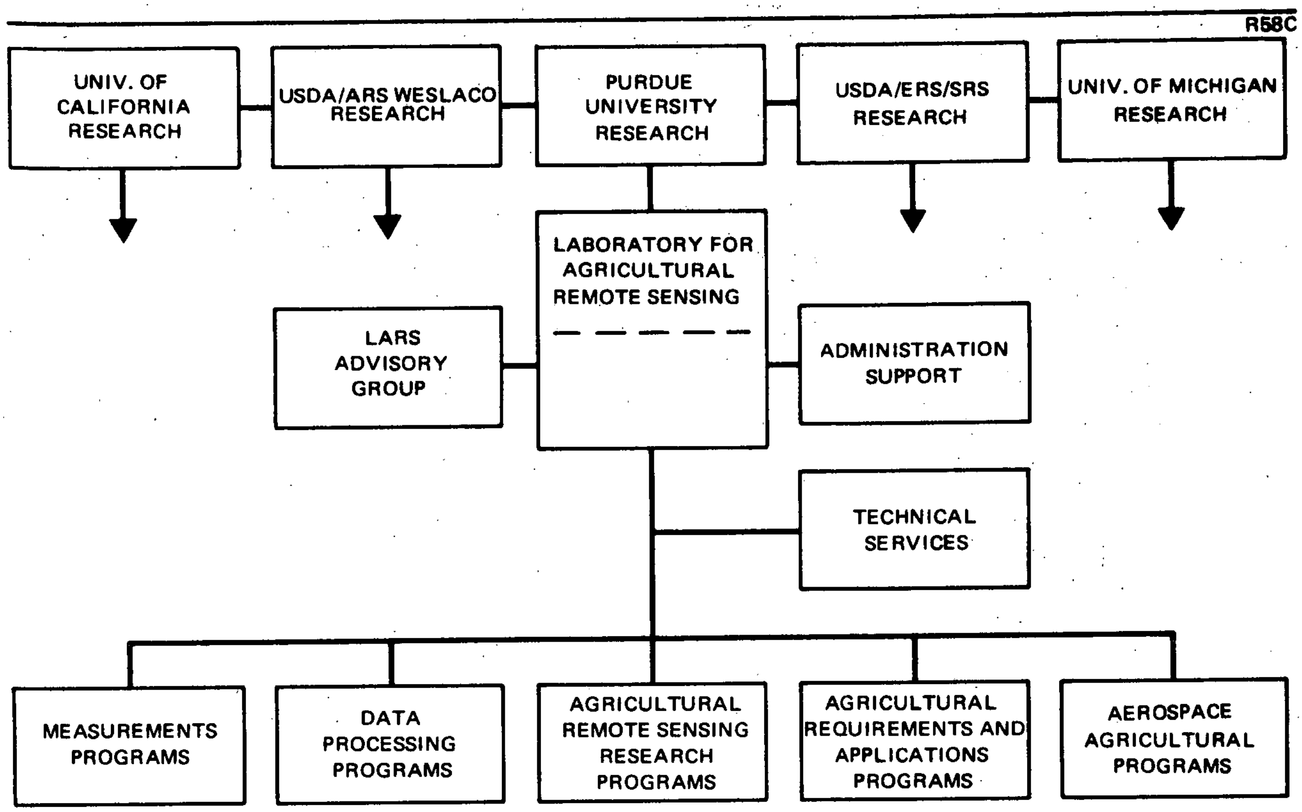


Figure 3. Cooperative NASA/USDA Remote Sensing Research Programs

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Soil Series Signature

2. BRIEF DESCRIPTION. Signature and computer identification of soil series.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-2, 6-A/F-5

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space and not in space to define present capabilities.*

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Recognize indigenous vegetation species and their vigor and relate to soil type and quality. Distinguish major soil types, e.g., aleuvial, igneous, sedimentary. Relationship between thriving and stunting of vegetation and soil properties, e.g., moisture, pH, trace elements, friability, etc. Signatures of chemical and mineral properties of soils in ultraviolet, visible and infrared portions of the spectrum. Sufficient experimental data to prove out existing computer models, such as that illustrated in Figure 1, and to develop new ones. Effect on soil temperature of depth of surface drying, surface texture, and vegetation cover for flammability research.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current research of USDA has successfully determined surface soil boundaries and areas possessing similar surface characteristics and has performed automatic analyses of data. It has

*Experiments should be performed concurrently in space, on the ground, and in the air.

been found that soil texture (size of soil particles) and soil structure (arrangement of these particles) have an influence on the type of vegetation grown. Other factors such as location, acidity and past history have a contributing effect on vegetative growth that cause differences in the multi-spectral responses received for any given species of vegetation. All of the above soil and vegetative factors directly, or indirectly, affect the amount of soil moisture available for use by plants. As vegetation matures, an observation of its condition of wilt or vigor will give an indication of available soil moisture.

Soil temperature also is a measure of soil moisture, since a wet soil is cooler than a dry soil. Soil moisture and soil temperature relationships need further study to determine their importance on the quantity and quality of energy that is emitted by the soil. It also has been observed that, spectral-wise, soils usually show gently changing reflectance up to 3μ, with some water band structure due to absorbed water. Soil moisture content appears to lower reflectance by a uniform factor except in the absorption bands. In the emissive range from 4μ to 15μ, green vegetation appears to be a gray body with little discernible emissivity structure, while soils usually show some optical phonon or restrahlen absorption between 8μ and 10μ.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EF-1, EF-3, EG-3

11. SUGGESTED DEVELOPMENT APPROACH(ES). The results of previous USDA/NASA experiments should be replicated using similar types of sensors from space including computer processing. Additional research should be undertaken at truth sites with simultaneous ground, airplane and space measurements.

12. SPECIAL FACILITIES REQUIRED. Truth sites containing a variety of soils that can be observed from towers, airplanes, and spacecraft. A computer must be available and a means to monitor the surface and atmosphere environment.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. USDA and NASA are conducting cooperative research at the following locations: (1) University of California, (2) Agricultural

Research Station, Weslaco, Texas, (3) Purdue University, (4) University of Michigan, and (5) USDA/ERS/SRS.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. This is an extension of a current effort and advancement will be continuous. Significant results should be obtainable within 3 years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 a year as follows:

	Year 1	Year 2	Year 3
Planning & Analysis	$300,000	$200,000	$100,000
Equipment	100,000	50,000	50,000
Ground Test Operations	75,000	50,000	50,000
Aircraft Test Operations	25,000	100,000	50,000
Space Test Operations	0	100,000	200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

R58C

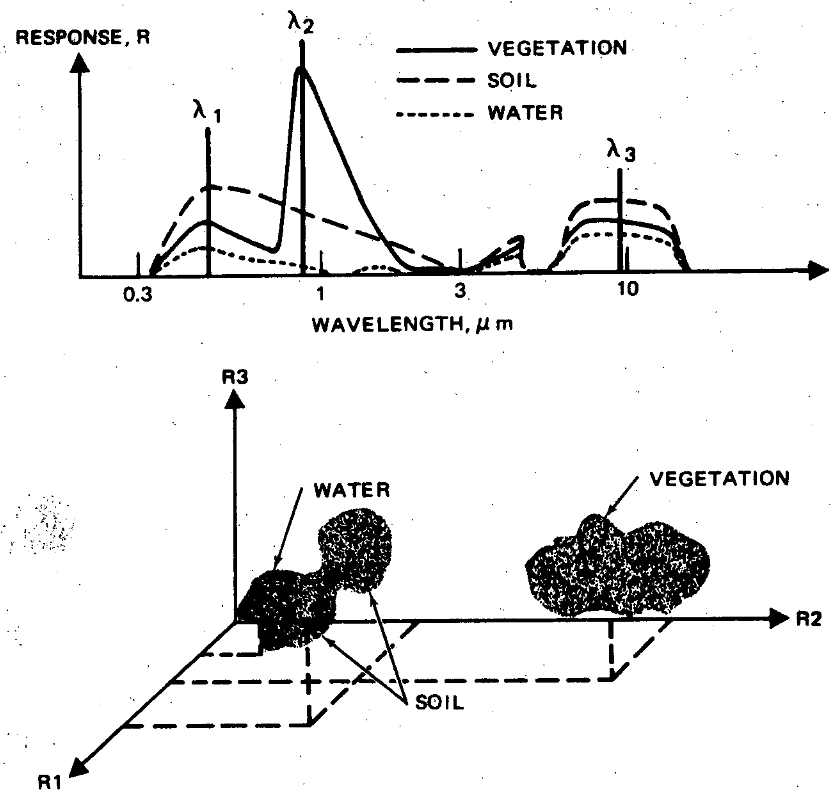


Figure 1. A Three-Dimensional Representation of Response Curves for Vegetation, Soil, and Water

The relative responses of vegetation, soil, and water can be employed to delineate the boundaries between them, using computer recognition. The measured response R from an object in each spectral interval represents the components of an n-dimensional vector. If three bands are chosen, the response from the object can be plotted in three-dimensional space (R_1, R_2, and R_3), as shown. If a series of measurements are made, the natural variations in the responses will form clusters of points as illustrated in the lower portion of the figure. The actual identification of soil, water, or vegetation can be made on a statistical basis by a computer. If a great many bands are used (i.e., 5 or 10), perhaps the soil series can be identified. (Figure from R. A. Holmes, "An Agricultural Remote Sensing Information System," EASCON 1968, Conference Research, p. 148.)

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Crop Yield Signature

2. BRIEF DESCRIPTION. Signature and computer evaluation of vigor and potential yield of crops.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-4

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space and not in space to define present capabilities.*

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Relationship between optical properties, such as spectral emittance and reflectance and physical properties, such as leaf wilt, and the vigor of vegetation. Effect of level of vigor of vegetation. Effect of level of vigor on ultimate size and qualify of harvest. Signatures that identify the cause of specific stunting or flourishing of growth for example, lack of soil moisture as illustrated in Figure 1. Sufficient experimental data to prove out existing computer models and to develop new ones.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Detection of vigor loss by detecting changes in chlorophyll absorption reflection has been done successfully from aircraft. Examples of the results are shown in Figure 2 and these should be verified from space. Research is

*Experiments should be performed concurrently in space, on the ground, and in the air.

proposed on relating a state of vigor to a specific cause and estimating the associated change in yield. The physical laws which influence the reflectance, emittance, and transmission of radiant energy from plants, soil, and water are not well understood.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- Some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EF-1, EF-2, EG-3.

11. SUGGESTED DEVELOPMENT APPROACH(ES). The results of previous USDA/NASA experiments should be replicated from space using similar types of sensors, including computer processing. Additional research should be undertaken at truth sites with simultaneous ground, airplane, and space measurements.

12. SPECIAL FACILITIES REQUIRED. Truth sites where vegetation can be subjected to a variety of stresses and the results observed from towers, airplanes, and space. Computer must be available and means to monitor surface and atmosphere environment.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. USDA and NASA are conducting cooperative research at the following locations: (1) University of California, (2) Agricultural Research Station, Weslaco, Texas, (3) Purdue University, (4) University of Michigan, and (5) USDA/ERS/SRS.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 a year as follows:

	Year 1	Year 2	Year 3
Planning & Analysis	$250,000	$200,000	$150,000
Equipment	100,000	50,000	50,000
Ground Test Operations	100,000	50,000	50,000
Aircraft Test Operations	50,000	100,000	50,000
Space Test Operations	0	100,000	250,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

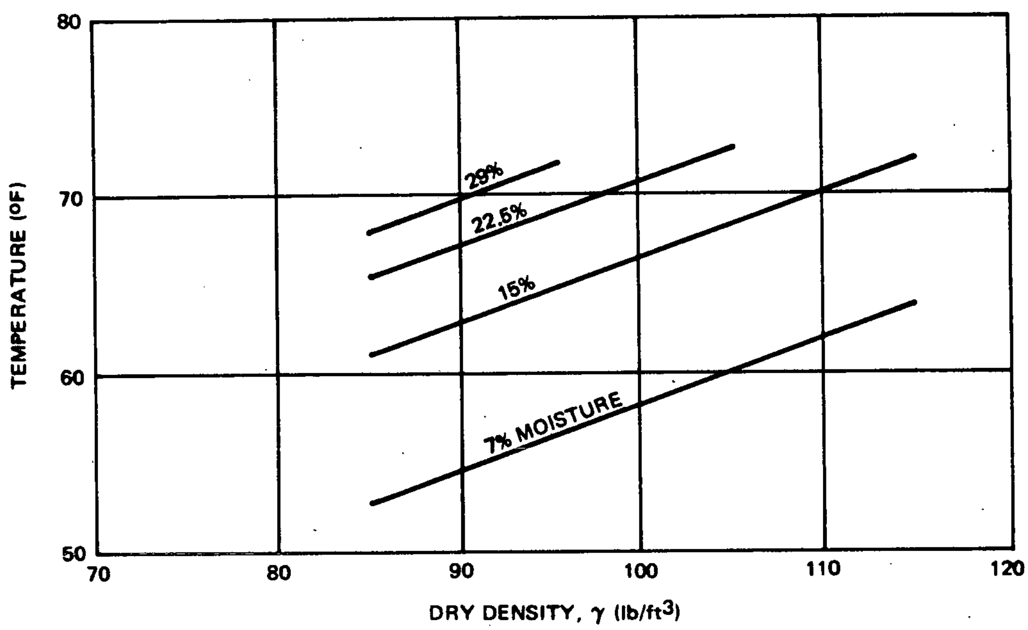
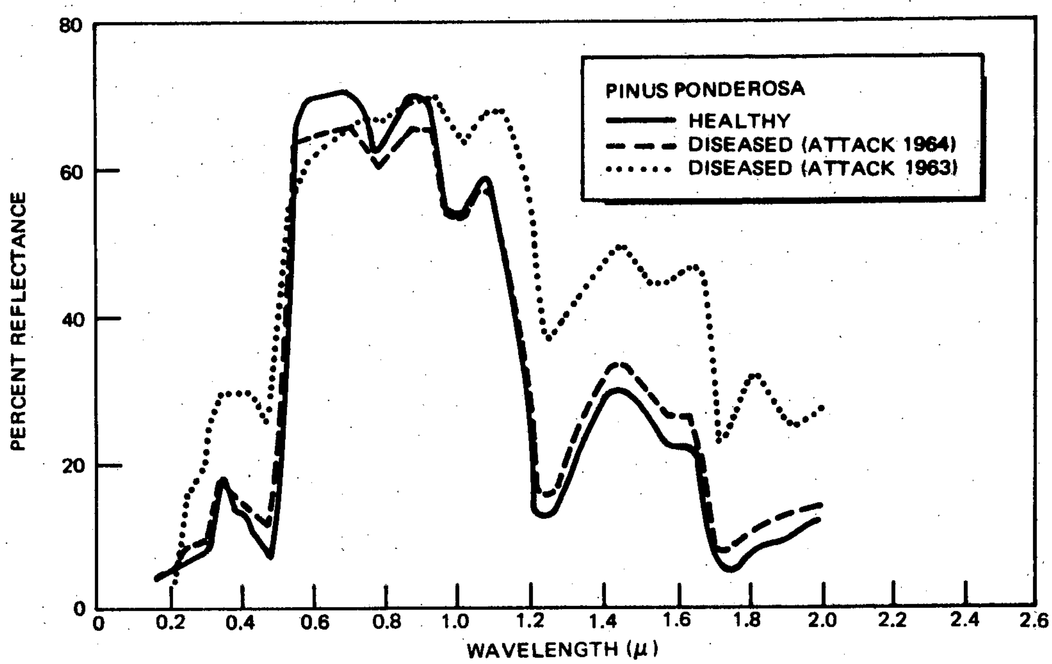


Figure 1. Dependence of Soil-Surface Temperature on Moisture and Soil Compaction

The above figure shows surface temperature versus density representative of silt or clay soil at 0500 hr on a clear summer night. This figure illustrates the calculated dependence of temperature on the density (compaction) and moisture content of soils, the temperature being proportional to the density and moisture. Night-time thermal imagery shows that water and wet soil are hotter than dry soil; during the day, the water and wet soil are cooler than dry soil. The temporal variations of thermal contrast measured with an infrared radiometer can provide a clue to the soil's moisture content.



From J. C. Schleter, V. R. Weidner and J. D. Kuder, "Spectral Properties of Naturally Occurring and Man-Made Materials." National Bureau of Standards Report 8626, December 1964.

Figure 2. Reflectances of Healthy and Diseased Ponderosa Pine

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Quantification of Volcanic Morphology.

2. BRIEF DESCRIPTION. Experimentation to quantify volcanic morphology.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-EP-2; 6-G-6; (Important) 6-G-3,-4

4. ITEM NO(S). Synopsis No. 5 6-G-3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Knowledge of volcanological structures, their growth rates, morphologies, heat flow, and mechanisms of eruption is far from satisfactory. Morphological data is lacking on the features shown in Table 1 for over 80 percent of all volcanic features of the world. The reason for this paucity of data is that many areas are in underdeveloped nations of the world, such as Indonesia, where modern mapping techniques have not been applied. In order to identify volcanic activity from spacecraft, a program of examining volcanic provinces on the earth should be inaugurated with emphasis on the measurement of those features or parameters that can be sensed from spacecraft. The fact that a volcanic feature has changed cannot be established unless high quality geomorphological data is available to use as a base on which to measure this change.

Table 1

DESIRED QUANTIFICATION OF
VOLCANOLOGICAL FEATURES

Morphological parameters of Earth observations interest

- Diameter of features
- Depth
- Diameter-depth ratio
- Central volcano height to rim height to diameter ratios
- Circularity index of craters
- Centralness of internal features of calderas
- Orientation of internal features of calderas
  - Faults
  - Crater chains
  - Dikes
- Terraces width and heights
- Tangential features
- Distribution of flank structures
- Slope angles: Rim, terrace, interior volcano, flank
- Other features: Length/depth of rim grabens, morphology of lava tubes, diameter/depth and distribution of volcanic bomb impact craters, depth and distribution of pyroclastics

Form and structure

Tectonic setting

Volcanic activity

Hydrothermal alteration

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Present methods of obtaining quantitative data of the type listed in Table 1 are within the state-of-the-art. Barringer type UV absorption spectrometry of crater fumes to provide a base line for sensing of SO_2 from altitude has not been applied to volcanology, but there is no reason why it should not provide useful data from instrumentation carried in conventional aircraft as a prelude to analysis by spacecraft.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Theodolite and photogrammetric surveys of volcanic features with ground party control. Aircraft photography from suitable altitudes, together with UV absorption spectrometry where needed.

12. SPECIAL FACILITIES REQUIRED. Instrumented aircraft and geological field parties.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. A considerable literature on instrumented aircraft sensing of volcanic features has been published by the U.S. Geological Survey, the Air Force Cambridge Research Laboratories, and Arthur D. Little, Inc., for Mono Craters, Reykjanes, and Surtsey areas, respectively. Programs for the aircraft thermal sensing of Kilauea, in Hawaii, also are in progress by the U.S. Geological Survey.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Results from a one-year program would materially improve data returned by orbiting spacecraft.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for geological research party; $250,000 for supporting instrumented aircraft surveys.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Signature of Rocks

2. BRIEF DESCRIPTION. Evaluation of multispectral signature of rocks.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-2, 6-EP-1, 6-G/C-1, 6-G-1, 6-G-2, 6-G-5.

4. ITEM NO(S). Synopsis No. 5 6-G/C-1

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The response of a sandstone to many sensors is known, but signature data is lacking for a sandstone that is partly argillitized or for a sandstone that has been highly vitrified by alteration. For many areas affected by facies change or hydrothermal or weathering alteration, the sensor will "see", not the end members which are sold by mineral supply houses, but the real world. The significance of being able to tell sandstone that has only 20 percent clay from one with 40 percent may mean a multimillion dollar decision in drilling for oil. Also, to sense a difference between an unaltered versus an altered sandstone can be important in predicting an ore deposit. The same reasoning may be applied with other rock types. More field and laboratory data are required to detect subtle but meaningful changes in host rocks that relate to geological mapping and the presence of ore or fossil fuel deposits.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The mechanism by which facies or alteration types develop is well known. The response of hybrid or altered rocks to infrared radiation has been looked at for a small number of samples by Drs. R. Lyons, J. Salisbury, and others. Response in the UV is also poorly known for this group of rocks. Microwave radiometry research has not been published on hydrothermal rocks. Infrared scanning may be meaningful because of the heat liberated by oxidation of Pyrite in certain altered volcanics but no data have been published on this phenomenon. The equipment for doing this research and the samples on which to do them are available.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EG-3, EF-2, EH-4

11. SUGGESTED DEVELOPMENT APPROACH(ES). Infrared and microwave radiometric scanning before and after rainfall on selected facies types and altered rocks.

12. SPECIAL FACILITIES REQUIRED. Instrumented aircraft, geological survey party, and remote sensing laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None specific to this type of research. Some ground truth studies by Martin, Marietta, have some isolated remote sensing scans, however, that are pertinent.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Results of a one-year's effort would materially improve return data from spacecraft.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000 per year (for laboratory instrumentation such as passive microwave, IR imagery, multispectral photography, etc.). $200,000 per year for laboratory personnel). $800,000 per year (for field surveys with instrumented aircraft).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Signature of Rock and Soil Types

2. BRIEF DESCRIPTION. Evaluation of multispectral signature of rock and soil types.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-2; 6-EP-1, -2; 6-G/C-1; 6-G-1, 2, 3, 4, 5, 6; 6-H-5, 6, 7

4. ITEM NO(S). Synopsis No. 5 6-G/C-1, 6-G-1

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. It is essential from orbit to be able to identify rock type, texture, and their degree of alteration. Whereas ground truth site work will provide some of the controls for the ground truth targets recommended, a much broader study of the response of earth materials to the sensors employed is required. At the ground truth sites, for example, the sensing survey may take place when the ground is dry. More data will be required on the response of the same assemblage of rock and soil types when they are wet or frozen. Very commonly, the production of patterned ground by frost is unique to the matrix material and particularly its grain size and shape. What is the correlation of electrical resistivity with infrared anomalies? In Iceland, the resistivity is low where there is an infrared high. Also, more research is needed on correlation of microseisms with sensor anomalies.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Geological, geophysical, and geochemical mapping are becoming increasingly sophisticated with the advert of better surface-detecting instrumentation - the cesium magnetometers, the field chemical spot tests, the laser theodolites. Operation capability is high and the results outstanding when used by an experienced observer. To co-join these talents with that of the orbiting observer/ experimenter is the goal of the research recommended.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EF-2, EG-2.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Expand current geoscientific ground truth surveys to other areas on a continuing basis, or the existing ground truth areas over a longer time period.

12. SPECIAL FACILITIES REQUIRED. Modern geoscientific field and laboratory equipment.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Current activities of the United States Geological Survey, University of Michigan, and aerospace science laboratories.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Results of first year's effort would improve performance of spacecraft. Extended program recommended.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$200,000 per year.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCE. MENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Waste Flow Pattern Determination.

2. BRIEF DESCRIPTION. Evaluation of marker dyes as a means of forecasting waste flow patterns.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-H-6; (Important) 6-G-2, 6-H-7, 6-O-1

4. ITEM NO(S). Synopsis No. 5 6-G-2

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. For any storage area of wastes, the most important consideration is the containment of this waste so as not to contaminate the local water supply. For this reason, injection of dyes into fluids containing waste that is laterally injected in shales could be monitored by altitude sensors at convenient periods after dye-in-waste fluid injection. If the waste is confined without leak-through to the water table, then a synoptic survey of the area will not reveal any contamination. The advantage of this approach is that the dye can be introduced first before the risk of injection of say radioactive wastes is attempted. What is required is detection of trace amounts of dye that is easily sensed or is sensitive to certain wavelengths of a multiband sensor.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Numerous dyes are available that can be sensed at specific wavelengths. These have been developed for air-sea rescue. The geology of areas considered for radioactive waste disposal is also known. Directional permeability measurements, however, are sparce for the subsurface of these shale areas.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EG-5

11. SUGGESTED DEVELOPMENT APPROACH(ES). In areas where there is a known rate of flow through an aquifer, introduce known amounts of dye to which certain sensors are most sensitive and scan the discharge points by instrumented aircraft.

12. SPECIAL FACILITIES REQUIRED. Instrumented aircraft, known geological relationships of aquifers, and known directional permeability of shales.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA/MSC aircraft earth resources program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Initial tests could be made in six months in known aquifers or in underground rivers of the Snake River Plateau. A thorough program for the horizontally bedded shale waste dump sites would involve a two-year program.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $80,000 (for first six-month phase). $350,000 (for entire two-year phase).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Signature-Waste Storage Sites

2. BRIEF DESCRIPTION. Evaluation of multispectral signature-waste storage sites.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-G-2; (Important) 6-H-6

4. ITEM NO(S). Synopsis No. 5 6-G-2

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. From orbital sensing, it is desired to determine possible storage areas for wastes. These fall into three main categories: shale injection sites, salt mines, and caves. An analysis of all three types of storage areas is required from a geological and hydrological viewpoint to see if these sites are truly feasible over short and long time periods. For shale injection sites, it is necessary to ascertain if remote sensing can distinguish shales from other rock types and, if possible, determine if they are fissile or massive. Horizontal bedding is another requirement for fluid waste injection from well bores into shales. For salt mines, the detection capabilities are not stringent in the United States because most of them have been located. However, for overseas waste disposal sites, remote sensing of salt domes needs to be refined. The geology of these domes also needs more study as does that of karst terrain.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. As far as surface and subsurface mapping techniques are concerned, the present level of understanding and technology is adequate for providing the geological control necessary to evaluate the types of waste storage sites. However, from the standpoint of detecting these sites and the specific characteristics of each site for waste storage, there is much more work to be done on their spectral response from high altitudes.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EG-4.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study of aerial photographs where shale injection of radioactive wastes has been carried on. Extrapolate photogrammetric data to unknown areas and do field analysis. Repeat for salt domes and cave areas.

12. SPECIAL FACILITIES REQUIRED. Geological research, interpretation of aerial photography and laboratory sensing of samples, study of aerial imagery from different altitudes with both surface and subsurface ground control.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The study of the geology of potential waste disposal sites could be integrated with other remote sensing programs of the Department of the Interior.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Probably data critical to orbiting laboratory could be obtained within three years. However, present sites used for waste confinement must be continually monitored.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 per year.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Laser Interferometer System

2. BRIEF DESCRIPTION. Development of surface laser interferometer relay system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED.

3. RESEARCH CLUSTER(S). (Critical) 6-G-3; (Important) 6-EP-2, 6-G-2*

4. ITEM NO(S). Synopsis No. 2 6-G-3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities; development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Relationship of the microvariations of laser interferometric strain gages to earthquakes are just beginning to be understood. Clear correlation of nuclear explosion tremors to discontinuities in laser interferometric records has already been established. The ability to relay laser interferometric records of faults or volcanoes near population centers to orbiting spacecraft will require a surface communications system.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A fairly sophisticated level of understanding of laser interferometry has been presented in several journal articles by J. Gauger and V. Vali of the University of Washington. To obtain unambiguous results, a modified Fabry-Pero or an unequal-arm Michelson interferometer must be used with a source of laser light. It is then necessary for the coherence length of the light beam to exceed twice the arm

*Subsidence effects on terrain created by artificially produced lakes (behind dams).

length of the interferometer; the coherence length, being defined by $l = C/\Delta f$ where C is the velocity of light and Δf is the bandwidth of the laser light. Minute movement of fault blocks can be measured by this technique to one part in a billion.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- Some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This system is ultimately part of the Ground Station Data Collection System (See STD EI-10).

11. SUGGESTED DEVELOPMENT APPROACH(ES). Implement laser interferometric detection equipment across the San Andreas fault and correlate micromovements with earthquakes.

12. SPECIAL FACILITIES REQUIRED. Ground-based laser interferometers in tunnels or mines cutting faults.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Laser Interferometric measurements have been made in the 3 mile tunnel at Stevens Pass, State of Washington and in a 0.1 mile tunnel of the Big Blue Mine, near Kernville, California. The latter tunnel cuts the Kern River fault. Both of these projects have been run by Dr. V. Vali of the University of Washington. At the Big Blue Mine, strains induced by the January 25, 1968 nuclear explosion amounted to 100 fringes or one part in a million.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Depending upon earthquake activity in the test areas, about one year to prove feasibility and four more years to rigorously quantify microdisplacements with impending earthquakes.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$80,000 (for instrumentation). \$20,000 (for geological surveying). \$90,000 (for spacecraft telemetering system) \$45,000 (for interpretation of records).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High.

F

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Signature of Geothermal Sources

2. BRIEF DESCRIPTION. Evaluation of multispectral signature of geothermal sources.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-EP-2; 6-G-4, -5

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The spectral signatures of a geothermal field over long time periods are not yet known. Most synoptic terrain observations are affected by time-dependent variables such as diurnal and seasonal warming and cooling cycle of the area scanned. More quantitative data are required of background noise in IR scanning created by variations in micrometeorological factors and emissivity of surface materials. More data are also needed to determine the threshold of detectability of heat flow in hydrothermal systems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. More and more publications in remote sensing highlight the key role of airborne infrared lines scan imaging systems in geophysical exploration and environmental control to record variations in broadband thermal emission from the earth's surface. These scanners are designed for sensitivity to IR radiation between 3.0μ - 4.1μ, 4.5μ - 5.5μ and 8 - 14μ. Factors involved in the equation $W = \epsilon\sigma\,(T^4 - To^4)$ are well known, where W is the differential radiant flux emitted

per unit area, ϵ is the emissivity factor, σ is the Stephan-Boltsmann constant (1.354×10^{-12} cal. cm^{-2} deg.$^{-4}$ sec^{-1}). T is the absolute temperature (°K) and To is the absolute temperature of the surrounding area (°K).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experiment results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Provide a closely controlled geological study of a thermal area which already has available data on influx and outflux flow rates and temperatures.

12. SPECIAL FACILITIES REQUIRED. Geological survey team for measurement of rock and fluid temperatures and emissivities at time of overflight of instrumented aircraft.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Experimental flights have been flown over the Salton Sea geothermal site on 22 May, 2 July, and 11 August 1970 by the U.S. Marine Corps in cooperation with McDonnell Douglas Corporation. Identical film and filter combinations were used on each flight.

The film and sensors used are as follows:

Color with haze filter	0.410 - 0.690μ
IR color	0.510 - 0.900μ
Black and white	0.470 - 0.610μ (with Wratten 58)
	0.590 - 0.700μ (with Wratten 25A)
IR thermal scanner	Beyond 1μ
IR black and white	0.700 - 0.900μ (with Wratten 89B)
	0.800 - 0.900μ (with Wratten 87C)

Extremely detailed synoptic data have been obtained at the south end of the Salton Sea as well as for experimental crop areas near El Centro (3 x 4 mile plot), sand dunes east of El Centro, the Sierra Estrella range, and an experimental crop area (4 x 4 mile plot) south of Phoenix. Some of this work was done in cooperation with Dr. R. Colwell of the Department of Forestry at UC Berkeley, and with the U.S. Geological Survey at Phoenix. Much supporting data was given to the principal investigator, Mr. M. Steinsnyder (MDAC-West) by the Department of Agriculture and the

Salt River Conservation project of El Centro and Phoenix respectively. Supporting aircraft (two RF-4Bs) were provided by Lt. Col. Percival of the Third Marine Air Wing, El Toro Marine Base, California.

In all sorties, ground control in the form of samples and climatic data were obtained at the time of overpass. In the laboratory, water content of the samples collected was determined. Correlation of imagery with environmental conditions, soil type, moisture content, etc., are currently in progress.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$50,000 (aircraft sensing before and after rainfall and at periods of earthquakes in the Salton Sea area). $45,000 (ground surveys). $30,000 (laboratory analysis). $40,000 (report preparation).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Fourier Transform Analysis of Landforms

2. BRIEF DESCRIPTION. Evaluation of Fourier transform analysis of landforms.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-G-5, 6-G-6

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Inputs for Fourier transforms generated with coherent light are the types of two-dimensional displays provided by the remote sensing program. What is required is an experiment program to determine if optical diffraction techniques provide a meaningful method of electronically sorting out the enormous amount of photographic data to provide significant data. The technology and operational capability are here, but much more interpretative work on photographs is required where the ground truth is of the resolution sufficient to put the Fourier transform to quantitative test. Which filter combination provides the output images that yield the maximum amount of information? Do the Fourier amplitude transforms show features of geological significance? These are the fundamental questions asked of optical diffraction imagery.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The optical principles on which the Fourier transform are made have been known since 1873, but only through the use of the laser has it made the method practical. With suitable optics a laser beam can be passed through a transparency, producing

a diffraction pattern or transform that is a statistical diagram of the spacings (inverse of spatial frequency) and orientations in the original material. The result is a polar coordinate diagram in which the radial and angular coordinates are functionally related to spacings and directions respectively in the input. The original image can be reconstructed from this pattern.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study the Fourier transforms of photographs taken at different wavelengths of terrain geologically understood and morphologically well defined. Compare the data of Fourier transforms with the geological facts.

12. SPECIAL FACILITIES REQUIRED. Conventional laser transform equipment. Geological maps and photography of surveyed terrain.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Fourier transform analyses have been made by the University of Michigan of El Solitario Dome, Texas; Pelly Bay, Canada; Phoenix, Arizona; Contra Costa County, California; Grants Pass, Oregon; Ouachita Mountains, Oklahoma; and Aristarchus on the Moon. Agencies active in these studies are ESSA, the Department of Agriculture, and the Department of Transportation.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 (including geological surveys of test areas).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Thermal Sensing of Seamounts

2. BRIEF DESCRIPTION. Evaluation of thermal sensing techniques to locate seamounts upwellings.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-G-6

4. ITEM NO. Synopsis No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The use of remote sensors to define new fishing banks involves the detection of areas marked by the upwelling of nutrient-rich waters. These waters have larger-than-normal amounts of oxygen, phosphates and nitrogen associated with them. These nutrients cause phyto- and zoo-plankton blooms thereby causing large fish populations. Remote sensing of nutrient-rich water is unlikely but detection of the thermal highs by IR or microwave radiometric techniques is feasible. Temperature differences in excess of 1°K exist above seamounts where the upwelling water may be as much as 3 to 5° K cooler than the surrounding water. It is required to detect the tori of cold water upwelling around seamounts. The seamounts themselves are of volcanological and logistic significance.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This method of locating seamounts and the resulting fish population is as yet untried. Aircraft flight tests are within the state-of-the-art.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Prepare a temperature contour map above a known seamount by conventional sea surface survey. Compare this map with one obtained in an aircraft equipped with passive radiometry and IR imagery.

12. SPECIAL FACILITIES REQUIRED. Sensing equipment; ocean-going vessel, instrumented aircraft.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Water Pollution Identification Techniques

2. BRIEF DESCRIPTION. Evaluation of water pollution identification techniques.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-H-1

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Evaluate relative performance of various water pollution identification techniques. Aircraft overflights of surface truth sites are required to define the multispectral signatures of various types of contamination, including saline, chemical, radiological, thermal, and biological. Flight evaluation is required to determine specific instrument operating characteristics which will yield maximum information return. Advanced techniques such as the use of laser stimulation of chemical luminescence require further evaluation. Basic instrumentation is metric and multispectral cameras, and multispectral radiometer.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. General techniques for identifying water pollutants have been established but require detailed correlation with ground truth data.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Aircraft flight program to gather data simultaneously with surface sensors.

12. SPECIAL FACILITIES REQUIRED. Aircraft test facility and surface sensor platforms.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA/MSC aircraft flight program; Federal Water Pollution Control Administration.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000 (excluding instrumentation).

16. ESTIMATEOF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Snow/Ice Depth Measurement Techniques

2. BRIEF DESCRIPTION. Evaluation of microwave techniques for determining snow/ice depth.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-H-4

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Evaluation of microwave techniques and instrumentation for the determination of snow and ice depth, temperature, degree of compaction, and water runoff rate.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Preliminary theory and testing have indicated that microwave radiometry may have potential for determining depth and/or water content of ice and snow fields. However, more theory and testing is required to develop quantitative signatures. Aerojet General has conducted field experiments along with theoretical modeling for the U.S. Geological Survey. Measurements have been made of natural and artificial snowpacks in situ at 21, 6, 2.2, and 0.8 centimeter wavelengths. This work was reported at the Third Annual Earth Resources Program Review, 1-3 December 1970, NASA/MSC.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Aircraft flight program to gather data simultaneously with surface sensors.

12. SPECIAL FACILITIES REQUIRED. Aircraft test facility and ground truth data stations.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. U.S. Geological Survey work with Aerojet General.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

STD ITEM
NO. EH-3

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Model of Snow/Ice Depth Signature

2. BRIEF DESCRIPTION. Study of a model of the microwave signature of snow and ice depth.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-H-4

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An analytical model of the microwave signature of snow and ice depth is required. Parameters to be considered are frequency, polarization, and incidence angle as correlated with snow moisture content, depth, degree of compaction, and temperature.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some modeling of microwave return from snow and ice has been done, along with laboratory and field investigations. These studies indicate considerable potential for the monitoring of ice and snow with microwave radiometry. Modeling, along with field investigation, has been conducted by Aerojet-General Corporation sponsored by the U.S. Geological Survey. Recent work in this area has been reported at the Third Annual Earth Resources Program Review, 1-3 December 1970, NASA-MSC.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None, although results of field experiments must be taken into account (see STD No. EH-2).

11. SUGGESTED DEVELOPMENT APPROACH(ES). Theoretical study is required.

12. SPECIAL FACILITIES REQUIRED. Computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. U.S. Geological Survey with NASA/MSFC.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Soil Moisture Measurement Techniques

2. BRIEF DESCRIPTION. Evaluation of microwave radiometry for determination of soil moisture content.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-H-5

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Evaluate microwave radiometry as a means for determining the degree of moisture contained in various types of soils. The amounts of water contained in both liquid and frozen states (such as permafrost) are to be measured. The effects of microwave frequency, polarization, and incidence angle on obtaining the required data are to be evaluated.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Preliminary experiments indicate a correlation between soil moisture content and the polarization of the microwave return.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EG-3, EF-2

11. SUGGESTED DEVELOPMENT APPROACH(ES). Aircraft flights over ground truth sites.

12. SPECIAL FACILITIES REQUIRED. Aircraft flight test facility and surface truth data station.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA/ Manned Spacecraft Center earth resources program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmosphere Boundary Layer Model.

2. BRIEF DESCRIPTION. Study of atmosphere boundary layer modeling.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-1; (Important) 5-P-2, 5-CS-1

4. ITEM NO. Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Models of convection and boundary layer conditions are required in order to fully develop field experiments in these areas. Models should include effects of downward westerly momentum transport upon large scale cyclonic activity. The effect of the spatial redistribution of the heat of condensation produced by severe storm systems must also be included. The effects of the fluxes associated with individual storm cells upon meso and larger scale activities and forecasts must be determined.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A number of prototype models are available. However, each of these tends to specialize with specific aspects of the problem rather than dealing with the entire system. F. W. Murray of Rand Corporation has compiled "An Annotated Bibliography of Dynamic Cloud Modeling," Memo RM-5582-ESSA, March 1968.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-2, EM-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Coordination with work of Global Atmospheric Research Program.

12. SPECIAL FACILITIES REQUIRED. A computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Global Atmospheric Research Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmosphere Effects from Surface Alterations

2. BRIEF DESCRIPTION. Study and evaluation of atmospheric effects from surface alterations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-1, 5-P-2, 5-CS-1

4. ITEM NO. Synopsis No. 3, Research Cluster No. 2

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The effect of alteration of surface conditions and the potential effects on weather modification must be studied in field experiments. Field experiments to measure the effects on energy exchange that can be brought about by altering the albedo, surface roughness, moisture content, and thermal and radioactive properties of surface material. Numerical studies of these boundary-layer exchanges must also be pursued.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Very little field experimentation has been completed that was associated with the alteration of surface characteristics. Data are available for different surfaces, degrees of roughness, etc. Some prototype boundary-layer models do exist.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-1

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of field experiments at Colorado State University under the Department of Interior.

12. SPECIAL FACILITIES REQUIRED. Large land areas where surface modifications can be accomplished and computer facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Work is under way at Colorado State University.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT 6 Months (for Study). 1 1/2 Years (for field experiments).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100, 000 (for Study). $300, 000 (for field experiments).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sferics Data Interpretation

2. BRIEF DESCRIPTION. Evaluation of sferics data interpretation and correlation.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-2

4. ITEM NO. Synopsis No. 5, Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Experimental data must be analyzed to determine what radio-noise, other than lightning-associated sferics, are generated by convective clouds. The relationship between these radio noises and the growth rate of the convective clouds should be studied. The possibility of detecting special noise effects associated with tornadoes or very severe thunderstorms should also be considered. The sferics signature of nonprecipitating cumulus clouds, mild thunderstorms, severe thunderstorms, and tornadoes should be determined.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Several ground based sferics networks were established, one by U.S. Air Force Weather Service and one by the Severe Weather Warning Service of the U.S. Weather Bureau. None of these networks are operational at the present time. Ground-based data was not sufficiently reliable to be incorporated into meteorological forecasting. However, such data would be useful in the establishment of a space-based observational system.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of Oklahoma State University research.

12. SPECIAL FACILITIES REQUIRED. UHF receiver and computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Limited research in thunderstorm sferics is under way at Oklahoma State University.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 3 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Stellar Scintillation Effects

2. BRIEF DESCRIPTION. Evaluation of stellar scintillation effects on the determination of atmospheric density by stellar occultation

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-3

4. ITEM NO. Synopsis No. 5, Research Cluster No. 3, 4

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The effects of varying air masses, moisture contents and temperature on stellar scintillation must be measured. In addition, the effect of scattered moonlight must be studied and measured. These measurements may be made with a readily available star tracker if the data can be scaled to the operation of the star tracker used in the research cluster 6-M-3.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theoretical relationships have been developed but little or no test data is available.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Scintillation measurements on star trackers flying on unmanned vehicles may be possible.

12. SPECIAL FACILITIES REQUIRED. This must be tested in space, therefore, an orbital facility is required.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300,000 (including cost of a star-tracker and data analysis).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmosphere Density Data Applications

2. BRIEF DESCRIPTION. Study of atmosphere density data applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-3

4. ITEM NO. Synopsis No. 2, 3; Research Cluster No. 2

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. In order to extend numerical weather predictions beyond 4 days, it is necessary to measure the initial state of the atmosphere on a hemispheric, and eventually, on a global basis. Accurate density, temperature, and absolute height data are required as inputs to compute the pressure-height field over the hemisphere. It is necessary to evaluate the effect of greater observation coverage and better data on prediction capability and accuracy.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Only 20 percent of the Earth's surface is now covered by upper-air observing stations. This is one of the main limitations on numerical weather predictions.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). This work could best be incorporated into the National Meteorological Center Computing Program.

12. SPECIAL FACILITIES REQUIRED. Computing facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Experiments in numerical weather prediction. Global Atmospheric Research Program is conducting similar efforts.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmosphere Density by Dual Spacecraft

2. BRIEF DESCRIPTION. Evaluation of density profiling by microwave transmission between master/slave orbiting stations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-3

4. ITEM NO. Synopsis No. 3, 5; Research Cluster No. 4

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Accurate measurements of satellite attitudes, antenna patterns, transmitter strength, and receiver gain are required. Transmitter strength decay or receiver gain decay during flight must be known. Measurements are averages over about 1,000 km near the lowest point in the atmosphere penetrated by the ray from one satellite to the other. The orbits of both satellites must be accurately known to calculate the average density along the path from the observed attenuation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Measurements which could provide the upper boundary condition for atmospheric prediction calculations are unavailable over 80 percent of the globe. This limits the accuracy and utility of numerical weather-prediction methods.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Possibly could be done by two unmanned satellites.

12. SPECIAL FACILITIES REQUIRED. Orbital facility and slave satellite.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Numerical experiments in long-range weather prediction at ESSA, Princeton, UCLA, etc. Master/slave satellite studies at MIT.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months (for slave satellite development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 (for slave satellite development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

STD ITEM
NO. EM-7

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Zero-G Cloud Physics Laboratory

2. BRIEF DESCRIPTION. Study and development of a zero-g cloud physics laboratory.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-4

4. ITEM NO. Synopsis No. 3, 4; Research Cluster No. 4

TYPE OF STD EFFORT

5. ACTIVITIES. Study; development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The development of a zero-g cloud physics laboratory is required in order to provide a space facility wherein a variety of cloud physics experiments could be accomplished for a large number of principal investigators. Immediate needs include: (1) a scientific investigation including a requirements study, experiment priority development, experiment sequencing and protocols, and astronaut training requirements, and (2) an engineering investigation including cloud chamber design requirements, instrument and support system requirements, spacecraft-cloud chamber facility accommodation, and optical system, and data processing requirements. Future requirements include; (1) apparatus design including lab tests and equipment design, spacecraft interface analysis, feasibility demonstrations and engineering modeling, (2) special astronaut training, (3) flight hardware development including flight article development, flight worthiness tests, spacecraft installation specifications, mission procedures and ground support equipment, and (4) spacecraft installation including experiment installation, system checkout, launch support and mission simulation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
MDAC-West developed the concept of the zero-g laboratory and is currently doing preliminary studies and development work.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-9, EM-10

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study of applicability of ground-based research laboratory equipment for use in space.

12. SPECIAL FACILITIES REQUIRED. Computer.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Research at MDAC-West.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
1 Year (for study). 2 Years (for development).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$150,000 (for study). $400,000 to $800,000 (for development).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Aerosol-Droplet Handling

2. BRIEF DESCRIPTION. Basic physics of aerosol-droplet-cloud chamber relationships. Includes introduction of material to chamber, techniques of control and maneuvering within chamber, and purging and cleaning chamber.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-4

4. ITEM NO. Synopsis No. 3, 4; Research Cluster No. 4

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space to define present capabilities.

6. OBJECTIVES. Theory; Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The basic requirement is to determine what, if any, special equipment is required for the astronaut to introduce, maneuver, change, observe, measure, and remove aerosols, droplets, gases, etc., in the zero-g cloud chamber. Most of the unknowns can be determined by a simple carry-on experiment on Skylab A or equivalent vehicles. Knowledge required includes but is not limited to the answers to such questions as: (1) Can droplets be introduced to chamber with hypodermic type needle? (2) Can suitable drops or particles be grown in chamber? (3) How long can a droplet remain suspended? (4) Can electric charge be introduced or removed from particle? (5) What techniques are available for purging? (6) What are effects of crew motion on suspended particles? (7) Is there size limitation on droplets in zero-g? (8) What is best design of chamber for astronaut visibility? (9) Can a droplet be split or can two droplets be combined? (10) What are effects of solutions?

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. None of the stated questions have ever been tested in a zero-g environment. They are all preliminary operations for the conduct of condensation-precipitation cloud physics experiments.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). This should be constructed as a carry-on experiment for Skylab A or on earliest possible manned mission.

12. SPECIAL FACILITIES REQUIRED. Zero-g environment.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This could be part of overall zero-g cloud physics laboratory program study currently under way at MDAC-West.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $30, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cloud Physics Experiment Priority Development.

2. BRIEF DESCRIPTION. Study of cloud physics experiment priority development.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-4

4. ITEM NO(S). Synopsis No. 3, 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. It is anticipated that the zero-g cloud physics laboratory will be an international facility and that many experimenters will want to take advantage of this unique capability. An impartial scientific team must evaluate all proposals, establish priority for inclusion on space missions, and determine interrelationships with other experiments. This scientific group could be a part of the National Center for Atmospheric Research (NCAR) and would be closely involved with NASA for funding and mission planning.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. No single center exists where broad-based scientific expertise is available for this type of decision making.

PROGRAMMATIC ASPECTS

9. CRITICAL RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-10

11. SUGGESTED DEVELOPMENT APPROACH(ES). Representatives of NAS, NSF, NCAR, NASA, and ESSA should be contacted for recommendations for establishing, locating, and staffing a scientific experimenters priority task force.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Cloud Physics Laboratory - Related Uses.

2. BRIEF DESCRIPTION. Study of cloud physics laboratory - related uses.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-4

4. ITEM NO(S). Synposis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The zero-g laboratory was conceived as a componentlized system and the possibility of utilizing this area in space for other research purposes should be investigated. Areas include: (1) fluid physics such as bubble motion, boiling, heat transfer, chemical combustion, interface stability, capillary studies, and propellant transfer; and (2) metallurgical research such as crystal growth, float zone refining, metal foams, controlled solidification, super cooling, electrostatic positioning, and new forms of glass.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The only published material is conceptual in nature and very little has been done to date.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-9

11. SUGGESTED DEVELOPMENT APPROACH(ES). Representative of NAS, NSF, NCAR, NASA, and ESSA should investigate multidiscipline use of the zero-g cloud physics facility.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $300, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Coherent Radiation Pollution Detection

2. BRIEF DESCRIPTION. Evaluation of coherent radiation pollution detection techniques.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-5

4. ITEM NO(S). Synposis No. 1, 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. In addition to present level of understanding, we need to know more about the strength of the Resonance/Raman effect from laboratory measurements. Also, at present, parametric oscillators give very little power compared to their counterparts, the fixed frequency lasers. It is necessary to determine what ultimate and practical powers may be expected from such oscillators. Lasers require large electrical power and elaborate coolant circulation systems to handle heat developed in power supply and laser cavity. Use of lasers from satellites to remotely sense and determine pollutants in the troposphere have the following general, but severe constraints: (1) day and night background emission limits detector system sensitivity, (2) attenuation of laser beam by clouds and gases between target and satellite, (3) laser hazards and eye protection at ground level, and (4) laser power and heat dissipation problems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The use of lasers as sources for air pollution analysis involves two competing but universal analysis techniques: (1) scattering spectroscopy, and (2) absorption spectroscopy.

The obvious methods in which lasers could be used for air pollution analysis are: (1) laser light can be Raman scattered (inelastic) by the gaseous pollutant molecules, the scattered light consists of line spectra and can be spectroscopally analyzed and, in principle, the pollutant amount and composition determined; (2) pulsed laser light can be elastically scattered (Rayleigh and Mie scattering) by pollutants, especially by suspended particulate matter, and distance and reflectivity of particulates can be measured; (3) laser light losses (attenuation) can be measured as the light traverses a column of sample; (4) a combination of Items (2) and (3); and (5) use tunable laser and measure directly the absorption or reflection of all the pollutants.

Of the methods described, Items (2), (3), and (4) are used in lidar mode. These methods are not specifically for any given pollutant, but are useful for measuring opacity and amount of particulate matter in suspension.

Methods described in Items (1) and (5) are for determining specific gaseous pollutant components. The advantages and disadvantages of these methods follow.

A laser-Raman system has the following advantages: (1) the existence of coherent, visible and near UV, single frequency, high power, lasers which bring the detection of specific vibration bands of the pollutants to a region of the spectrum where detection techniques are very good; and (2) instrumentation is already available. The main disadvantage of this laser-Raman technique for air pollution analysis is that the Raman effect is a second-order effect and thus, weak by its own nature. It is weaker than Mie and Rayleigh scattering, and resonance absorption. However, in principal it can be enhanced so that it is much stronger than Rayleigh scattering. This is accomplished by utilizing a laser source with frequency in one of the electronic bands of the specific molecular pollutant.

In the present technology, three or four lasers will be candidates for resonance-Raman source. For instance, the frequency quadrupled YAG-Nd laser which can obtain powers of 1 watt at 2,650 Å.

The use of specific absorptions of laser light by molecules requires that the laser frequency be made coincident with specific absorption frequencies of each of the pollutants to be analyzed. However, normal tuning techniques will not allow the detection of all important pollutants. The only way to do absorption spectroscopy is to make a tunable laser. This can be constructed for use in the near infrared region for absorption spectroscopy, or for resonance-Raman-spectroscopy at optical and UV wavelengths.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- same required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-12

11. SUGGESTED DEVELOPMENT APPROACH(ES). Use of aircraft measurements to confirm laboratory testing.

12. SPECIAL FACILITIES REQUIRED. Electro-optics laboratory and aircraft test facility with ground truth sites.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Air Pollution Control Agency programs.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmosphere Pollution Signature Analysis

2. BRIEF DESCRIPTION. Evaluation of atmospheric pollution multispectral signatures.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-5

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Air pollutants may be classified by various properties but for remote detection purposes their spectroscopic properties are important. These properties arise as a consequence of the emission or absorption of light by electronic, vibrational, and rotational quantum transitions of the pollutant molecules. The resulting spectroscopic signature is specific for each gaseous pollutant. Therefore, it is important and essential to know what are the pollutants and their spectra, and what signal changes in the UV, visible, IR, and microwave are expected between clean and polluted atmospheres. An assortment of ground based measurements with spectroscopic-photometric equipment is needed in order to establish which detection techniques (passive versus active) are actually best for specific pollutants.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some of the pollutants also are found as natural traces in the unpolluted atmosphere. Atmospheric radiation and the formation of spectral bands by specific atmospheric components and pollutants has been extensively studied and considerable literature

exists on the subject. Studies have been made to indicate the expected change in signal due to differences between clean and polluted air and to indicate which bands or spectral regions are best for specific molecules.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Flights of existing multispectral and microwave instruments over ground truth sites.

12. SPECIAL FACILITIES REQUIRED. Laboratory and aircraft testing, and a computer facility for data analysis.

13. KNOWN ONGOING ACTIVITES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Air Pollution Control Agency studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 4 Years (significant results after 2 years).

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200, 000 per year (excluding instrumentation for aircraft flights and data analysis).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Atmospheric Model of Pollution Effects

2. BRIEF DESCRIPTION. Study to produce an atmospheric model of pollution effects.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-5; (Important) 5-P-2, 5-CS-1

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Models of three dimensional space on all scales from small valley and large basin (Southern California) to global or hemispheric size are required to assist in prevention and control decisions. Currently, air pollution control consists primarily of observation, and very little prediction capability is shown. In order to predict and prevent the occurrence of fatal pollution episodes, an understanding of the atmospheric transport and pollution source interactions is necessary.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Basic models exist. As an example, MDAC-West has developed a hybrid computer simulation model for the Los Angeles basin. The model was used for control cost effectiveness and the simulation of low concentration chemical reactions. Model includes 16 input zones, 3 diurnal sources for automobiles, power stations and heavy industries, weather parameters including wind velocity and direction, inversion height, and sunlight and varying boundary conditions such as mountain-valley and inversion effects.

B

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EM-1

11. SUGGESTED DEVELOPMENT APPROACH(ES). Integration with National Air Pollution Center activities.

12. SPECIAL FACILITIES REQUIRED. Computer facilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This program should be integrated with the National Air Pollution Center activities.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $60, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Tropical Cloud Systems Model

2. BRIEF DESCRIPTION. Experiments to produce a model of tropical cloud systems.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-6; (Important) 5-P-2, 5-CS-1

4. ITEM NO(S). Synopsis No. 1, 2; Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. To observe and study the convective, boundary layer, and large-scale interaction occurring in wet-season cloud cluster disturbances of the tropics, a major field experiment is required. Current planning has an experiment scheduled for summer of 1973 in the Marshall Islands. Motion fields, radiation, thermal and moisture structure, and cloud distributions will be monitored on scales 100 to 1, 000 km. In special areas of convective activity, measurements will be conducted down to scales as low as a meter.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Currently the experiment includes use of: (1) geosynchronous satellite with visual and infrared imaging, (2) high-flying jet aircraft equipped with wind-measuring dropsondes, (3) long-range aircraft equipped with high-grade turbulence measurement systems, (4) surface and upper-air network of 25 ships or islands, (5) automatic recording anemometers and rain gauges, (6) weather radars with overlapping covers, and (7) an analysis and operations center.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Completion of the planned experiment in the Global Atmospheric Research Program.

12. SPECIAL FACILITIES REQUIRED. Extensive communication and data processing capabilities.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. This experiment is currently part of the Global Atmospheric Research Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million (for weather observation equipment). *
$2 Million (for 12 months operation of data analysis center). *

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

*Estimate exclude costs of operating aircraft, ships, and satellites.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Pollution Identification Techniques

2. BRIEF DESCRIPTION. Evaluation of ocean pollution identification techniques.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-1

4. ITEM NO(S). Synopsis No. 3, 5; Research Cluster No. 2, 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Evaluate relative performance of various ocean pollution identification techniques. Aircraft and surface truth measurements are required. Concentration of pollutants is to be measured to within one part per million, with a spatial resolution of 100 meters. Techniques to accomplish this require evaluation to identify problem areas and suitability for orbital operation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. General techniques to detect and/or identify pollution have been investigated. These include use of multispectral photography, spectrometry, and multichannel radiometry. Flight evaluation is required to determine specific instrument operating characteristics which will yield maximum information return. Theory and laboratory experiments indicate a possible application of laser coherent light to measure ocean pollutants by stimulated emission. Fraunhofer line discrimination technique also may be applicable to ocean pollution analysis.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Relates to results of EO-2.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Flight program to acquire data with several instruments simultaneous with ground truth data.

12. SPECIAL FACILITIES REQUIRED. Aircraft test facility and oceanographic research ship for on-sight tests.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THE STD REQUIREMENT COULD BE INTEGRATED. MDAC-West laboratory studies and U. S. Geological Survey Fraunhofer line-field studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Pollution Modeling

2. BRIEF DESCRIPTION. Pollution measurement model relating pollution parameters to absorptions, reflection, and emission parameters of the ocean and atmosphere.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-1

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. To improve ocean pollution measurement system design, theoretical numerical models are needed to relate emission and reflectance parameters of both the ocean and atmosphere to pollution parameters. Atmospheric emission and reflectance/scattering results in background noise that obscures the signals from the ocean.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Remote sensing techniques studied to detect or identify aspects of pollution include: (1) photography, (2) optical and IR spectrophotometry correlation spectroscopy, (3) stimulated emission, and (4) IR and microwave multichannel radiometry. Some laboratory spectrophotometric analyses of reflected light from different types of water have been performed. Data have been obtained with several instruments on aircraft which have covered the spectrum from optical through microwaves. Most have been concerned with oil or thermal pollution. No theoretical work has been discovered.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-1, EO-5, EO-12 and EO-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Theoretical and laboratory work on emission absorption and reflectance of incident light from ocean and atmosphere.

12. SPECIAL FACILITIES REQUIRED. Computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Heat Flow Measurement Techniques

2. BRIEF DESCRIPTION. Evaluation of multichannel microwave radiometry for sea surface heat flow measurements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-2

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The net heat flow at the air-sea interface is usually calculated from indirect data and therefore, is subject to large errors. Theory indicates that two appropriately chosen microwave frequencies can be used to directly measure the heat flow at the sea surface.

   The specific instrument characteristics necessary to provide sea temperature measurements ultimately to 0.01°C and sea surface heat flux to 0.01 - 0.1 watts/m^2-ster-μ must be determined.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Microwave radiometers which were not designed specifically for this application currently exist. Their effectiveness in measuring heat flow at the ocean surface with sufficient accuracy must be evaluated.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-11

11. SUGGESTED DEVELOPMENT APPROACH(ES). Use currently available multi-frequency radiometers in a research program with necessary ground truth to test hypothesis.

12. SPECIAL FACILITIES REQUIRED. Aircraft, multi-frequency radiometers, ship/buoys.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Dr. McAlester at Scripps Ocean Institute has developed a heat flow program using a two-channel IR radiometer. Space General has developed a multichannel microwave radiometer for NASA-MSC aircraft program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sea Surface Heating Model

2. BRIEF DESCRIPTION. Development of a model relating heat flow to sea surface temperature.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-2

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. To use the heat flow measurements taken by a dual channel microwave radiometer for temperature forecasting, it is necessary that a forecast model be developed. This model should be designed to use data on cloud cover, sea surface temperature, and heat flow plus other pertinent atmospheric and ocean parameters to forecast the sea surface temperature. Preliminary time periods needed are 1 day, 3 days, and 7 days.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A general equation is available that relates the various energy flux processes, but in most cases the individual elements are determined on an indirect time/space averaged basis.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer simulation model.

12. SPECIAL FACILITIES REQUIRED. Computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Fleet numerical weather central forecast activities and Dr. McAlester's heat flow program at Scripps Oceanographic Institute.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Chlorophyll Concentration Model

2. BRIEF DESCRIPTION. Study of a chlorophyll concentration model derived from ocean spectral signature.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-3

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 2, 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A model is needed that can relate the spectral distribution of reflected radiation quantitatively to chlorophyll concentration. This spectral data would be taken by a multispectral scanner or ocean color sensor.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Aircraft flights have shown that there is a significant variation of the ocean spectral distribution with chlorophyll concentration, pollution, etc. However, an analytical model is needed that relates these parameters.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-2, EO-12, EO-13, and EO-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer simulation.

12. SPECIAL FACILITIES REQUIRED. Computer

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. TRW/Woods Hole aircraft experiments of an ocean color sensor.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$50, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Population Measurement Techniques

2. BRIEF DESCRIPTION. Evaluation of methods using ocean color sensors, multispectral scanners, for measurement of population dynamics parameters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-O-3

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 2, 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define percent capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Determine if ocean color sensors, or multispectral scanners or cameras currently available can determine a spectral distribution to the precision and repeatability necessary to be useful in determining phytoplankton and fish-catch variability. Surface resolution of 100 meters is required, with phytoplankton population measurements on the order of $10/m^3$ and fish population on the order of tons per day for all fish types.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. To date it has been shown that multispectral radiometry and photography offer potential, but further evaluation is needed. For further details on ocean color sensor, see STD No. EI-6.

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PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-1, EO-3, EO-11, EO-12, and EO-15

11. SUGGESTED DEVELOPMENT APPROACH(ES). Coordinated flight data/ground truth data with model simulation.

12. SPECIAL FACILITIES REQUIRED. Aircraft, ship, and buoy support.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. TRW/Woods Hole field tests.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Fish/Chlorophyll Correlation Model

2. BRIEF DESCRIPTION. Development of a model relating chlorophyll concentration to fish production.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-3

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 2, 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A mathematical model is needed that relates photosynthesis as measured by chlorophyll concentration, to current and future fish population distribution.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some modeling has been done of population dynamics which may be adapted or modified for the stated purpose. For general background see J. A. Dyther, "Photosynthesis and Fish Production in the Sea," Science, 166 (1969) P 72-76.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer model.

12. SPECIAL FACILITIES REQUIRED. Computer

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Modeling of this type has been done at School of Fisheries, University of Washington.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Radar Determination of Sea Surface Height

2. BRIEF DESCRIPTION. Study relating atmospheric and sea surface parameters to radar signal return in the determination of sea surface height.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-4

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 2

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists to determine sea surface heights relative to the geoid to within 10 cm by 1972 and 3 cm by 1975. This requires an improvement in radar signal processing techniques and analysis of atmospheric and oceanic absorption, reflection, and refraction effects on radar signals.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some preliminary work on signal processing has been accomplished See R. K. Moore, "Radar and Data Processing," Proceedings of the Second Annual Earth Resources Aircraft Program Status Review, Vol. II, NASA MSC September 1969. Current status of modeling work is uncertain.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer modeling and laboratory testing of the interaction of radar with the sea surface and atmosphere.

12. SPECIAL FACILITIES REQUIRED. Computer and laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Dr. Moore at Kansas University and the Geophysical Science Laboratory at NYU have been studying the problem for use in radar altimetry.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Current Sea Height Model

2. BRIEF DESCRIPTION. Study of an ocean current/relative sea height model.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-4

4. ITEM NO(S). Synopsis No. 5; Research Cluster No. 2

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists to transform relative mean distance from the sea surface to the spacecraft into mean sea surface height relative to the geoid. The distance from the spacecraft to the center of the Earth is obtained from the spacecraft track. Altimetry provides the distance from the spacecraft to the mean sea surface. This data must be combined with knowledge of the geoid to provide the sea surface height relative to the geoid. Time and space variations of this relative mean sea surface height must then be related to surface and subsurface sea currents. The theory of how this is done must be fully defined and implemented in a computer model.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some theoretical discussion of this problem can be found in the following: (1) Greenwood, et al, "Oceanographic Applications of Radar Altimetry from a Spacecraft," Remote Sensing of Environment 1 (1969), P. 71-80, and (2) "Solid Earth and Ocean Physics," NASA Williamstown Seminar Report, 1968.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-12, EO-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Analytical model for computer simulation use.

12. SPECIAL FACILITIES REQUIRED. Computer.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NYU studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ice Distribution Model

2. BRIEF DESCRIPTION. Development of a model relating various measurements of temperature, pressure, and salinity to forecasts of ice distribution.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-5

4. ITEM NO(S). Synopsis No. 1, 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF THEORETICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists for sea ice forecasts for 1 day, 3 days, and 1 week. This requires a model of sea ice distribution and dynamics as a function of sea temperature, pressure, and salinity and atmospheric parameters such as precipitation, wind, temperature, and humidity.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Ice forecasts are prepared now but wholely on a subjective, empirical basis, using ice reports.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Empirical-theoretical development of computer model.

12. SPECIAL FACILITIES REQUIRED. Computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Naval Oceanographic Office Ice forecasts, and Fleet Numerical Weather Control, Monterey, California.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Salinity Measurement Techniques

2. BRIEF DESCRIPTION. Evaluation of microwave methods for remote measurement of ocean salinity.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-5

4. ITEM NO(S). Synopsis No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists to measure salinity to one part per thousand with a spatial resolution of at least 100 meters. Evaluate microwave techniques for this application.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Theoretically, salinity does affect the microwave emissivity of water. However, no measurement of this effect appears to have been made with radiometers*. The studies at MDAC-West indicate, for example, that at 20 cm wavelength, 20°C water temperature, and a salinity of 33.5 percent, a resolution of ± 0.7°K is needed to measure ± 1 part per thousand.

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*H. A. Hyatt, "Emission, Reflection and Absorption of Microwaves at a Smooth Air-Water Interface," Journal of Quantitative Spectroscope Radiation Transfer, 1970, pp. 217-247.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important - some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-3, EO-12

11. SUGGESTED DEVELOPMENT APPROACH(ES). Measurements of emissivity in Laboratory and from aircraft.

12. SPECIAL FACILITIES REQUIRED. Laboratory, aircraft, and ground truth.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Naval Oceanographic Office Space Oceanography Project.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 1 Year

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $150,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Physical Properties Model

2. BRIEF DESCRIPTION. Development and evaluation of a model relating absorption, emission, and reflection parameters to physical, chemical, and biological parameters.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-5

4. ITEM NO(S). Synopsis No. 1, 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. To relate the effects of the variations in composition, mixture, and suspensions on the reflectance and emission spectra of the ocean, a sophisticated mathematical model representing the essential physical, biological, and chemical processes is needed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Some work has been published relating the effects of salinity, temperature, and roughness to the emission and reflectance, but these models need refinement by means of laboratory and field measurements.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-2, EO-5, EO-13, EO-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Mathematical model with Laboratory and field measurements to modify and improve theory.

12. SPECIAL FACILITIES REQUIRED. Laboratory aircraft, and computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA-MSC Earth Resources Program, and Naval Oceanographic Office Spacecraft Oceanography Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $150,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Depth Model

2. BRIEF DESCRIPTION. Development and evaluation of a computational model relating remote sensor data with depth of the ocean floor.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-6

4. ITEM NO(S). Synopsis No. 3, 5; Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Study; experiments not in space to define present capabilities.

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists to be able to determine the depth of coastal water to nearest half foot from scattered radiation. Since discoloration from pollution and suspended particles will affect the interpretation of the measured irradiance, a model is necessary to take such factors into account.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Bottom contouring methods have been proposed using multispectral photography. However, no quantitative interpretation methods have been developed.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-2, EO-5, EO-12, EO-14, EO-16

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer modeling support by field measurements.

12. SPECIAL FACILITIES REQUIRED. Computer and aircraft.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Spacecraft Oceanographic Committee (Naval Oceanographic Office), Philco-Ford, and University of Michigan.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Low

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ocean Boundary Process Measurement Techniques.

2. BRIEF DESCRIPTION. Evaluation of methods to measure ocean boundary processes including erosion, longshore transport, and sedimentation.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-6

4. ITEM NO(S). Synopsis No. 2, 5; Research Cluster No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Measure shoreline and sea shelf currents to 0.1 knots, sediment load to 1 gram pm^3, linear distance to 10 meters, shoreline or shelf relief to 1 meter, wind velocity and direction to 1 knot and 10 degrees. Methods using currently available instrumentation require evaluation by field testing to determine ability to meet these requirements. These include use of multispectral photography, and multispectral radiometry.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Linear distance resolution is estimated to be on the order of 100 to 200 meters and vertical relief to ± 1 foot from orbital altitudes using photography. Other variables have not been determined by remote sensing.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Compare photography, return beam vidicons and multispectral scanners in flight test program as to information content, precision, and accuracy and resolution.

12. SPECIAL FACILITIES REQUIRED. Aircraft and ground truth.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA-MSC Earth Resources Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sea Surface Roughness Measurement Technique.

2. BRIEF DESCRIPTION. Evaluation of techniques for measuring sea surface roughness.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-7

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists for an instrument that can measure RMS sea height to ± 1/2 foot, and estimate shape of wave height spectra and direction spectra.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Data obtained have indicated a dependency of the radar scattering coefficient with wind speed and look angle (see R. K. Moore, and G. Bradley "Radar to Oceanography," Proc. 2nd Earth Resources Aircraft Program Status Review). However, Naval Research Laboratory measurements with a four-frequency radar system indicate a much smaller variation of the scattering coefficient curve with wind speed and frequency (see N. W. Guinard, and J. C. Daley, "An Experimental Study of a Sea Clutter Model,"Proceedings of the IEEE Vol. 58, No. 4, 1970, pp. 543-550). Further evaluation appears to be in order along with consideration of passive microwave radiometry.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-12

11. SUGGESTED DEVELOPMENT APPROACH(ES). Simultaneous measurements in aircraft and on surface.

12. SPECIAL FACILITIES REQUIRED. Ground truth and aircraft.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA-MSC Earth Resources Program and NRL studies.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Sea Surface Roughness Model

2. BRIEF DESCRIPTION. Improvement of models relating sensor outputs to physical parameters in the measurement of sea surface roughness.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-7

4. ITEM NO(S). Synopsis No. 5

TYPE OF STD EFFORT

5. ACTIVITIES. Study

6. OBJECTIVES. Theory

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A need exists for models that relate sea surface roughness parameters, atmospheric transmission parameters, and electromagnetic reflection and emission parameters to develop and evaluate improved systems.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Current models are not quantitative; only discriptive. Quantitative studies have been made of models relating reflection and emission to roughness parameters (see V. A. Sirounian, "Passive Microwave Radiometry of Sea State," MDAC-West Report, DAC-60786, September 1967).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-2, EO-5, EO-12, EO-13

11. SUGGESTED DEVELOPMENT APPROACH(ES). Computer simulation.

12. SPECIAL FACILITIES REQUIRED. Computer facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA/MSC Microwave Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Evaluation of Active/Passive Microwave Radiometry.

2. BRIEF DESCRIPTION. Evaluation of active/passive multispectral microwave radiometry for oceanographic measurements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-0-1, 2, 3; 6-0-5; 6-0-7

4. ITEM NO(S). Synopsis No. 5 6-0-7

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Evaluate active/passive multispectral microwave radiometry to gather information about ocean absorption, scattering, and emission parameters from which physical measurements such as temperature, salinity, sea roughness, cloud cover, precipitation, etc., can be determined.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Both passive microwave radiometry and active microwave systems (radar) have been proposed for oceanographic investigations. It appears that efficiency and synergetic value would accrue from such a combination. An active/passive microwave system has been proposed for Skylab A. Experiment S193A utilizes a passive microwave radiometer operating at 21-cm wavelength, and S193B employs an active microwave scatterometer operating at 3-cm wavelength.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. EO-15, EO-12

11. SUGGESTED DEVELOPMENT APPROACH(ES). Evaluate active/passive microwave methods via aircraft testing.

12. SPECIAL FACILITIES REQUIRED. Microwave instrumentation laboratory and aircraft test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. University of Kansas research.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 2 Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Twin Metric Camera

2. BRIEF DESCRIPTION. Two metric cameras and two stellar-reference cameras integrated into a single system.

SOURCE FROM WHICH THIS STD REQUIREMENTS IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4, -5; 6-EP-1; 6-G/C-1; 6-G-1, -2, -3, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-6; 6-O-6; (Important) 6-EP-2; 6-G-4; 6-M-1, -2, -5; 6-O-1, -2, -3, -4, -5, -7

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Two metric cameras and two stellar-reference cameras integrated into a single system. Interchangeable lens capability is desirable for system flexibility. Stereo and infrared photography is required. Operation in the infrared requires special focusing. For photogrammetry, a distortion of less than 2.5 microns across the film format is required. Field of view on ground is typically 200 x 300 nm or less. Ground resolution requirements are specified in the following table:

Twin Metric Camera-Ground Resolution Requirements

Research Cluster	Resolution (Feet)	Research Cluster	Resolution (Feet)
6-A/F-1	50 - 150	6-H-4	100
6-A/F-2	10 - 100	6-H-5	100
6-A/F-3	10 - 200	6-H-6	50
6-A/F-4	100 - 200	6-H-7	100
6-A/F-5	150	6-M-1	150
6-EP-1	1500	6-M-2	200
6-EP-2	100	6-M-3	NA
6-G/C-1	5 - 200	6-M-4	NA
6-G-1	100	6-M-5	12,000 - 18,000
6-G-2	100	6-M-6	150
6-G-3	100	6-O-1	300
6-G-4	100	6-O-2	300
6-G-5	100	6-O-3	300
6-G-6	100	6-O-4	300
6-H-1	100	6-O-5	300
6-H-2	100	6-O-6	30
6-H-3	100	6-O-7	1500

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY.
Cameras having a system resolution of 30 to 35 lp/mm, 40 to 75 deg. field of view and distortion of 3 to 5 microns are used for aerial photography. The film format is 9-1/2 inches square. A wide variety of non-interchangeable lenses with focal lengths of up to 24 inches and lens-film resolution of 50 to 90 lp/mm are advertised. A 24-inch focal length 30 lp/mm system has a ground resolution from 235 nm altitude of about 85 feet. A lunar topographic camera has been built by Hycon for internal operation aboard Apollo 14. This system has an 18-inch focal length and a 14-degree field of view. Apollo 16 is slated to carry a lunar metric camera externally. A single metric camera with two stellar reference cameras is under consideration for an advanced Skylab. This system has a field of view of 41° x 62° with a 12-inch focal length giving a ground resolution of 60 feet over 176 x 282 nm from 235 nm altitude. This system has a maximum distortion across the 9 x 14-inch format of 10 microns.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). The camera should be developed as a total system involving optics, film, camera structure, shutter mechanics, and space maintenance. The use of panoramic cameras, rather than just framing cameras, also should be investigated. A panoramic camera might be the better way to secure the needed field of view, long focal length, and small ground resolution element size.

12. SPECIAL FACILITIES REQUIRED. A capable camera manufacturer with a modern laboratory and range should be capable of developing the camera. Flight testing over a truth site should be done to prove out the overall design.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Typical problem areas being attacked are developing a dimensionally stable camera frame tying together the lens, between-the-lens shutter, diaphragm, fiducials, and a precisely flat vacuum platen. Designers are seeking a uniform level of illumination over the field and the freedom to interchange color and infrared emulsions without having to change focus or suffer distortion. Metric cameras are being flown in the NASA-MSC aircraft remote sensing program and one is under consideration for an advanced Skylab.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2.5 Million, as follows:

	Year 1	Year 2
Design	$ 200,000	$ 100,000
Test	150,000	350,000
Prototype	500,000	200,000
Flight Article	0	1,000,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Camera

2. BRIEF DESCRIPTION. Six-band multispectral camera.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4, -5; 6-EP-1; 6-G/C-1; 6-G-1, -2, -3, -5, -6; 6-H-1; 6-O-6; (Important) 6-EP-2; 6-G-4; 6-H-3; 6-H-7

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Six matched cameras commonly boresighted and synchronized for simultaneous photography. Six spectral bands are of interest: 0.5-0.6μ, 0.6-0.7μ, 0.7-0.8μ, 0.8-0.9μ with black and white film, and 0.5-0.88μ, 0.4-0.7μ with color films. Field of view on ground is typically 100 x 100 nm. Ground resolution requirements are as follows:

Multispectral Camera-Ground Resolution Requirements

Research Cluster	Resolution (Feet)	Research Cluster	Resolution (Feet)
6-A/F-1	75 - 150	6-G-2	100
6-A/F-2	75	6-G-3	100
6-A/F-3	100	6-G-4	100
6-A/F-4	30 - 100	6-G-5	100
6-A/F-5	20 - 200	6-G-6	100
6-EP-1	1500	6-H-1	100
6-EP-2	100	6-H-2	NA
6-G/C-1	30 - 200	6-H-3	200
6-G-1	100	6-H-4	NA

Research Cluster	Resolution (Feet)	Research Cluster	Resolution (Feet)
6-H-5	NA	6-M-6	NA
6-H-6	NA	6-O-1	NA
6-H-7	100	6-O-2	NA
6-M-1	NA	6-O-3	NA
6-M-2	NA	6-O-4	NA
6-M-3	NA	6-O-5	NA
6-M-4	NA	6-O-6	300
6-M-5	NA	6-O-7	NA

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Four Hasselblad 500-EL 70 mm format cameras were flown on Apollo 9 as an Earth-viewing multispectral photography experiment. Principal investigator was Paul D. Lawman of NASA-GSFC. A multispectral camera will be flown on Skylab A as Experiment S190. This system consists of six 70 mm cameras operating in the above spectral bands. Field of view is 88 x 88 nm, 21.2 degrees using approximately 200 mm focal length lenses. Ground resolution is 90 feet from 235 nm.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of Skylab camera, Experiment S190, for 70 mm format. New development for large format system.

12. SPECIAL FACILITIES REQUIRED. Photo optical instrumentation laboratory and aircraft flight test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Development of Multispectral Camera for Skylab A, Experiment S190, Itek Corp.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years for extension of existing Skylab Camera.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$1.5 Million, as follows:

	Year 1	Year 2
Design	$100,000	$ 50,000
Test	100,000	150,000
Prototype	100,000	200,000
Flight Article	0	800,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ten-Band Multispectral Scanner

2. BRIEF DESCRIPTION. Multispectral scanner radiometer in ten spectral bands.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3 -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1; 6-H-5, -6; 6-O-1, -2, -3; (Important) 6-H-3, -4; 6-H-7; 6-O-6

4. ITEM NO. Part II No. 3, Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. For the experiment groups previously identified the use of a multi-spectral imaging scanner is required. In the near-visual range, from 0.4 to 0.8 microns, both high spatial and spectral resolution are required, for identification of spectral signatures from small surface areas. Spatial resolution of 100 feet in conjunction with spectral resolution of 0.01 micron (100 Angstroms) would be an ultimate objective.

   Several experiments require the use of imagery in the thermal infrared range from 10.2 to 12.6 microns, for imaging of thermal patterns on the terrain or water surface. In this range, spatial resolution of 100 feet or better is a desirable objective. A temperature resolution of 0.2°K is also desired. Swath width requirements are typically 100 nm or less. For identification of agricultural species, disease, and soil types, optical subsystems should be developed for band centers as follows:

0.42μ	chlorophyll absorption	5.0μ	leaf temperature
0.55μ	reflectance in the green	10.0μ	leaf temperature

0.65μ	chlorophyll absorption	Preferable bandwidth range visible 0.04μ to LWIR 4.0μ
0.73μ	chlorophyll reflection	
0.86μ	chlorophyll reflection	
1.67μ	water absorption	Acceptable bandwidth range visible 0.1μ to LWIR 6.0μ

Cryogenic cooling will be required for detection in the thermal infrared range.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY
Contemporary multispectral imaging scanners use a small number of point detectors within each spectral band, in conjunction with a mechanical scanning system, consisting of an oscillating or nutating mirror for scanning of the object plane. Resolution values for typical objects on the terrain are 300 feet, in near-visual range, and 600 feet, in the thermal infrared range (resolution in ft/optical line-pair). Multispectral scanners of this type are a) the MSPS being developed by the Hughes Aircraft Company (SBRC) for the ERTS A and B satellites, and, b) the multispectral scanner currently being procured by NASA/MSC for the Skylab Program. The multispectral scanner for Skylab A, Experiment S192, has a 0.364 millirad resolution, yielding 520 feet ground resolution, over a swath width of 47 nm from 235 nm altitude. Development of a high resolution multispectral line scan sensor is currently being undertaken by NASA-Goddard.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). The signal-to-noise ratio and resolution (spectral and spatial) of a multispectral scanning system are dependent upon the number of photons incident upon the detector element during the dwell time required to scan one resolution element of the scene. By increasing the number of detector elements the angular field of view scanned by each element is decreased, resulting in an increase of the dwell time on each resolution element of the scene, and increasing the number of photons received by the detector element during this dwell time. By the use of very high density linear arrays of detectors, each consisting of a large number of detector elements (in the order of several thousand), the dwell time on each resolution

element can be increased to a maximum value limited only by the acceptable amount of image motion. By use of this approach, the maximum possible performance (S/N ratio and resolution) can be obtained (Figure 1). This should lead to an improved version of the Skylab A instrument.

12. SPECIAL FACILITIES REQUIRED. Facilities for production of high density linear detector arrays and microcircuit preamplifier and interrogation circuits. The type of detector arrays required are as follows: 0.45 - 1.1 microns silicon; 10.2 - 12.6 microns mercury cadmium telluride.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Current procurement from NASA Goddard Space Flight Center for study and breadboard model of a high resolution Earth Resources sensor system. A 21-band scanner for aircraft use has been built by Bendix for the University of Michigan.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5-10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

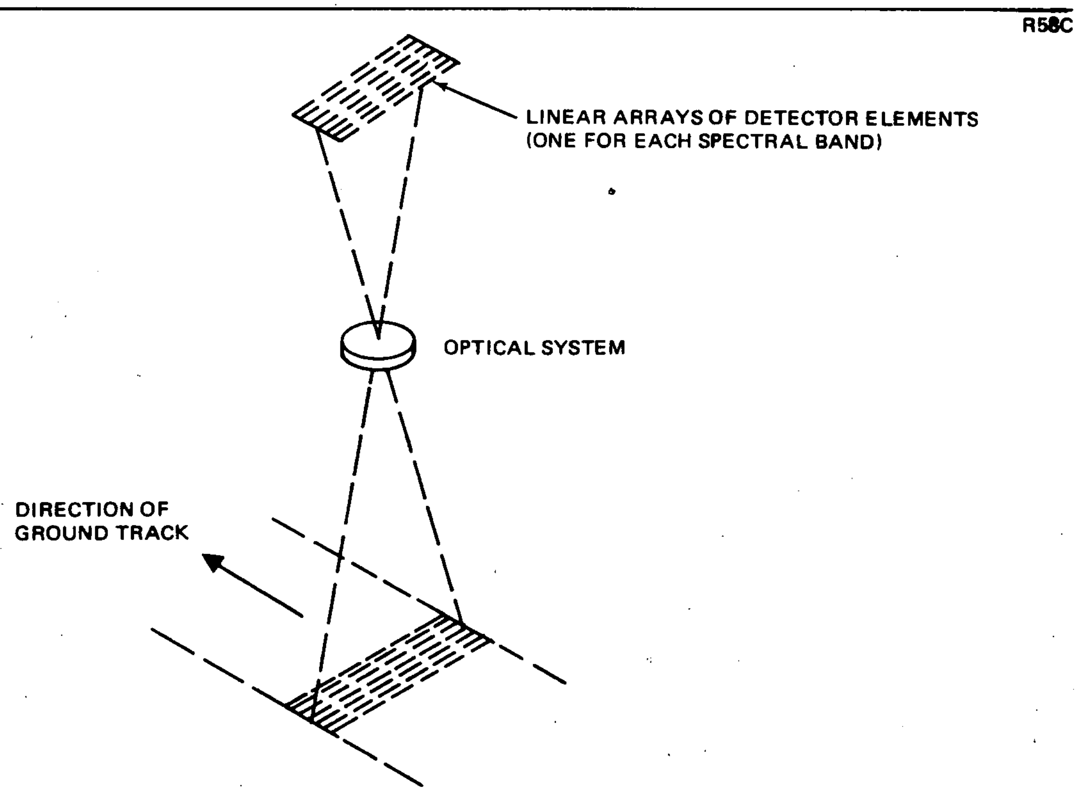

Figure 1. Conceptual Configuration High-Resolution Earth Resources Sensor

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Side-Looking Radar Imager

2. BRIEF DESCRIPTION. Side-looking synthetic aperture radar imager.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4; 6-G-3; 6-G-5; 6-H-2, -3, -4; 6-H-7; 6-O-5; (Important) 6-EP-2; 6-G-1, -2; 6-G-4; 6-G-6; 6-O-4

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A side-looking radar imager, preferably operating at X-band 5-10 GHz or higher, is needed for operation from orbit. Operation in L-band 0.4-1.5 GHz is acceptable. Horizontal and vertical polarization data is desired. Data is to be recorded photographically from an oscilloscope display. Ground resolution requirements are as follows:

Research Cluster*	Ground Resolution (feet)	Research Cluster*	Ground Resolution (feet)
6-A/F-1	50 - 150	6-G-5	200
6-A/F-2	100 - 300	6-G-6	200
6-A/F-3	10 - 100	6-H-2	200
6-A/F-4	100 - 500	6-H-3	200
6-EP-2	200	6-H-4	200
6-G-1	200	6-H-7	200
6-G-2	200	6-O-4	300 - 1500
6-G-3	200	6-O-5	30
6-G-4	200		

*Those research clusters not shown do not require the radar imager.

Significant problem areas requiring particular attention in the development of the radar imager are as follows: (1) methods of providing the high ground resolution together with swath widths greater than 20 miles; (2) stabilized mountings for focused radar systems that require precise knowledge of the instantaneous line-of-sight; (3) wave-form generation components for synthetic aperture systems that have much improved coherence and stability; (4) research in the range ambiguity phenomenon in high-pulse-rate systems that forces a reduction in swath width, particularly at satellite altitudes; (5) research in band-width influences on monochromatic radar to reduce target breakup or scintillation that produces a speckled appearance of imagery; (6) research in the effects of operative type, wavelength, polarization, direction of transmitted signal, and the surface electrical, roughness, and slope properties; and (7) research in the radar signatures of earth resources as a function of frequency, polarization, look angle, and antenna type.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An orbital radar imager was originally proposed for Apollo Applications. Radars have flown in the NASA-MSC Earth Resources Aircraft Program, but none have flown in space. A radar imager, proposed for Skylab B, has a 5-degree field of view and 0.1 millirad resolution (150 foot ground resolution from 235 nm). Another proposed Skylab B radar has a 0.02 millirad resolution (30 feet from 235 nm). Three types of radar are being considered in an attempt to achieve ground resolution of 100 feet or so with antennae of a practicable size. There are (1) conventional radar, where ideally, azimuth resolution = wavelength x range/antenna size = $\lambda R/D$, (2) unfocused synthetic array where azimuth resolution = $0.5\sqrt{\lambda R}$, and (3) focused synthetic antenna where resolution = $D/2$. The relative azimuth resolutions of each type are illustrated in Figure 1 for an X-band system. From the standpoint of antenna length, a focused radar is best; however, the swath widths are rather small (20 miles). An unfocused synthetic array has a larger, swath width (40 miles), which is better for mapping. Studies made using primarily a K-band radar in geologic mapping, drainage network, land use, and vegetation identification are discussed in the attached references.

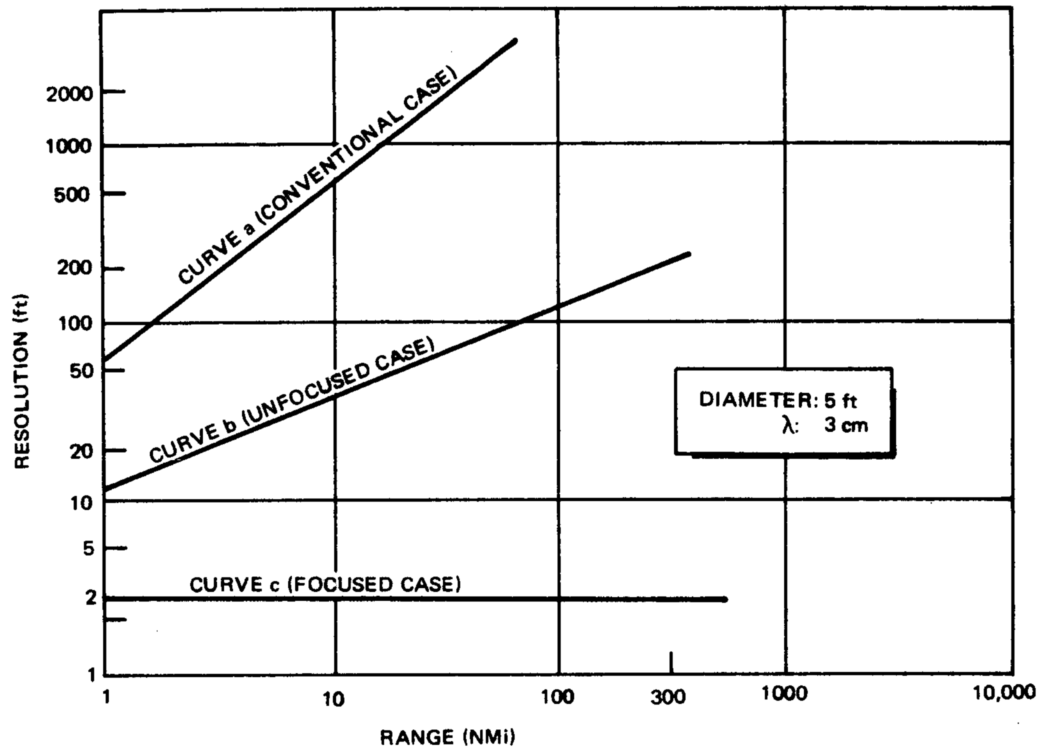

Figure 1. Resolution Versus Range for Three Cases (Idealized) After Reference 1.

References:

1. L. J. Cutrona. The Role of Synthetic Aperture Radar in Earth Resource Monitoring. Paper 70-315 AIAA, Earth Resources Observations and Information Systems Meeting, Annapolis, Md., March 1970.

2. D. S. Simonett. Remote Sensing With Imaging Radar: A Review. Short Course in Remote Sensing of the Environment, University California at Los Angeles, August 1970.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEM WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of proposed Skylab instruments.

12. SPECIAL FACILITIES REQUIRED. A radar manufacture and test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Testing of radar imaging concepts and techniques is part of the NASA-MSC Earth Resources Aircraft Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Four Years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $10 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. UV — Visible Absorption Spectrometer

2. BRIEF DESCRIPTION. Ultraviolet and visible wavelength absorption (correlation) spectrometer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-5; (Important) 6-G-5; 6-O-1

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments Not in Space to Define Present Capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An ultraviolet and visible wavelength absorption (correlation) spectrometer is needed for use from orbital altitudes. Ground resolution for research cluster 6-O-1 is 300 feet and for 6-G-5 and 6-M-5, 4 nm. Before development, it is necessary to determine the degree to which natural ultraviolet radiation reflected from the Earth can be detected at near satellite altitudes. Ozone is considered a potential problem as are the effects of scattering from clouds and aerosols and the effects of solar elevation and surface reflectivity. Further aircraft experimentation is required to assess these factors before a space-qualified instrument is developed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Variations of this instrument have been flown in aircraft programs since 1968. The aircraft design has a resolution of 1 degree, corresponding to 4 nm ground resolution from 235 nm altitude; spectral range is 2800-5000 Å. This instrument is a candidate for orbital flight aboard Nimbus E.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. For non-space experiments: EM-12 atmospheric pollution signature analysis.

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extend aircraft research to high altitudes.

12. SPECIAL FACILITIES REQUIRED. Laboratory and test facilities for spectrometer/radiometer type instruments.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. NIMBUS E, NASA-MSC Aircraft program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year for Experimentation; One Year for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Experimentation $200, 000; Development $700, 000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multi-Channel Ocean Color Sensor

2. BRIEF DESCRIPTION. Multi-channel ocean color sensor with 150 Å resolution over 0.4 to 0.7 microns wavelength.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-H-1; 6-O-1, -2, -3; (Important) 6-A/F-1, -2, -3, -4

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The feasibility of identifying oil slicks on ocean water by the use of photo-electric spectrophotometry has been demonstrated in aircraft flight tests (Reference 1). Typical results are illustrated in Figure 1. Spectral characteristics can identify phenomena such as concentration of phytoplankton, and can show the boundaries in areas of upwelling and sedimentation (Figure 2).

   The primary specifications for a photoelectric spectrometer for satellite application would be:

Spectral Resolution	- 150 Å	Spectral Range	- 4000 Å to 7000 Å
Spatial Resolution	- 1 nmi	Ground Coverage	- 150 nmi swath width

   Spatial resolution ultimately down to 300 feet is required by research clusters 6-O-1, 6-O-2, 6-O-3.

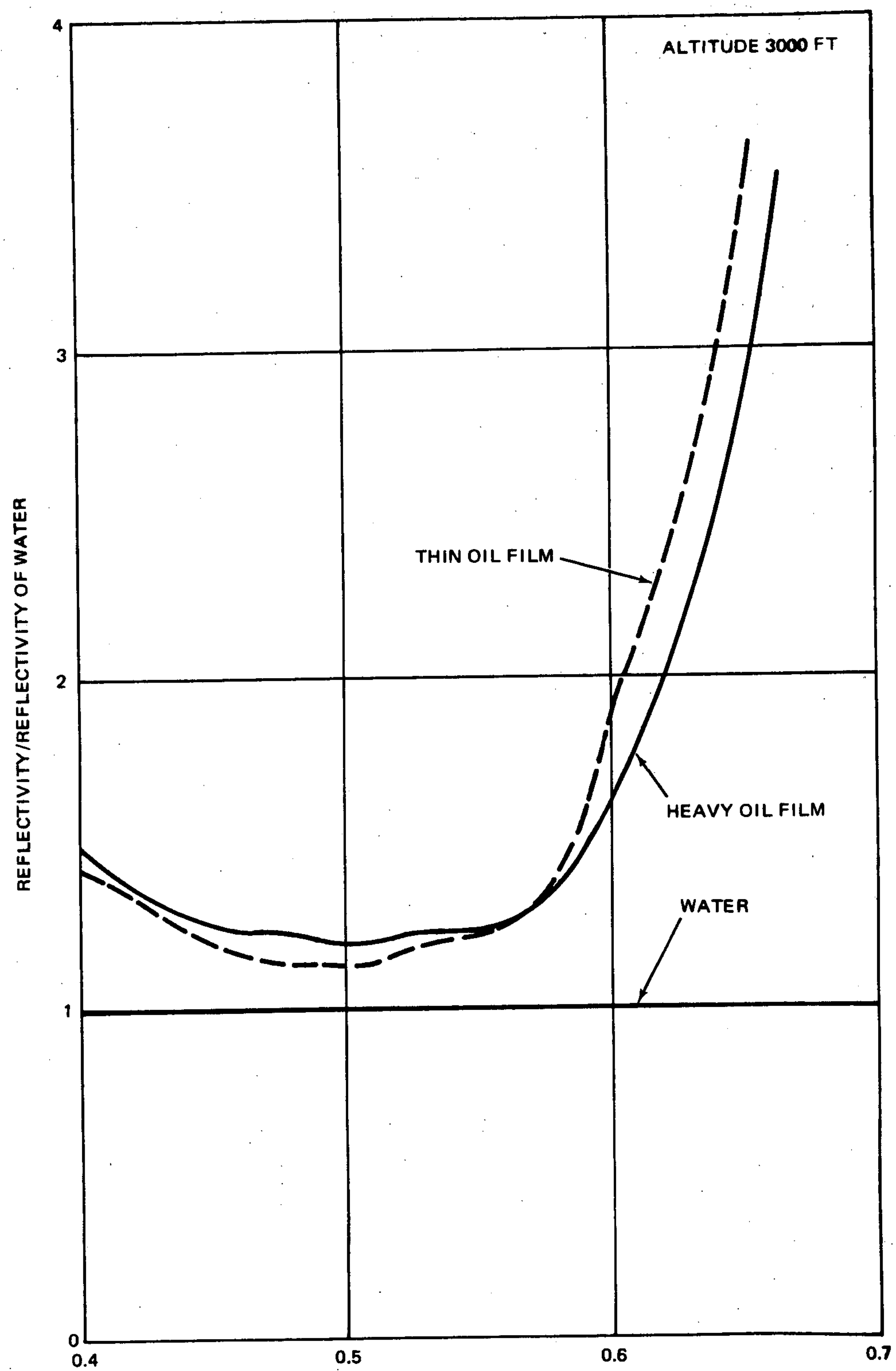

Figure 1. Relfectivity Ratio of Oil Covered Sea-Water to Normal Sea Water

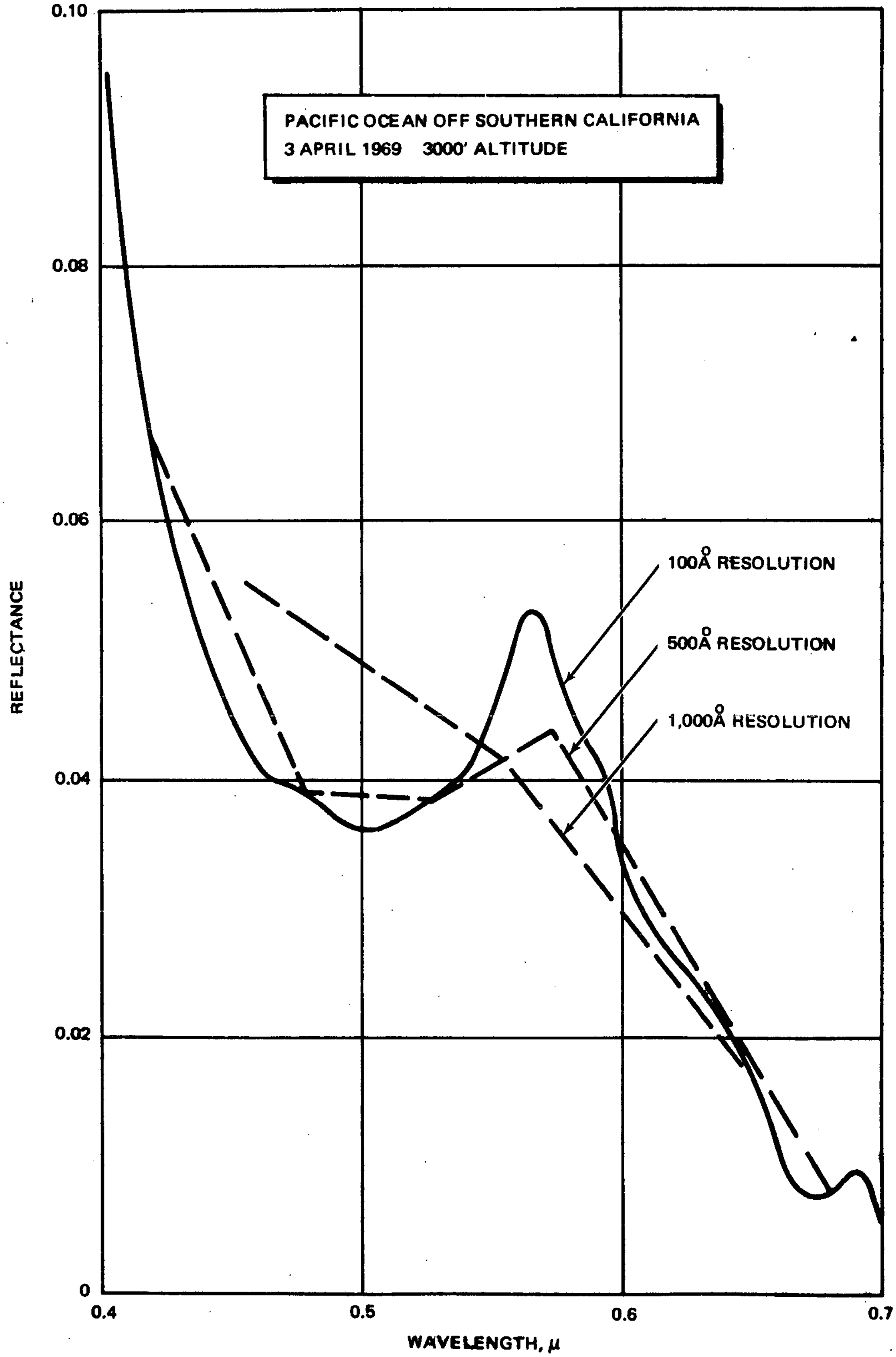

Figure 2. Remote Measurement of the Spectral Reflectance of Water with High Plankton (Gonyaulax) Content

Operation as an alternate to the 10-band multispectral scanner in agriculture/forestry requires resolution on the order of 100 feet.

Positive results obtained in aircraft flight tests make an instrument of this type a suitable candidate for space flight. The primary effort required is development of an instrument with the above specifications, and evaluation of performance from orbital altitude.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Feasibility of the technique has been demonstrated in aircraft flight tests. TRW development proposal to NASA Headquarters May, 1970. Aircraft version called SIS (Scanning Imaging Spectroradiometer) is under development for NASA-MSC. This system has a resolution, of 1.3 milliRad, which would yield 1,800 feet ground resolution from 235 nm. Field of view is 10 degrees, or 40 nm from 235 nm altitude.

(Reference 1 Peter G. White, "An Ocean Color Mapping System" TRW Systems Groups, TRW Inc., undated publication)

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Development and flight test of a space-qualified photoelectric spectrometer for spectral measurements of the color of the ocean and large bodies of fresh water.

12. SPECIAL FACILITIES REQUIRED. Electro-optics Instrumentation

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Undergoing evaluation as part of NASA-MSC aircraft program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 18 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

F

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Radar Altimeter/Scatterometer

2. BRIEF DESCRIPTION. Radar altimeter/scatterometer with application to agriculture and oceanography.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-0-2; 6-0-4; 6-0-7; (Important) 6-A/F-1; 6-0-6

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A radar altimeter scatterometer is required for operation from orbital altitudes. Spatial resolution required is on the order of 300 feet for oceanographic research clusters 6-0-2 and 6-0-4, 30 feet for 6-0-6 and 1500 feet for 6-0-7. Altitude accuracy of ± 3 cm is ultimately required by research cluster 6-0-4.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. No instrument has been developed for use in space. However, proposed for Skylab B is an instrument that has a spatial resolution of 5.5 nm and an altitude resolution of ± 3 feet from 235 nm altitude.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of proposed Skylab instrument.

12. SPECIAL FACILITIES REQUIRED. Radar Instrumentation Test Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NASA Earth Resources Aircraft Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Microwave Scanner Radiometer

2. BRIEF DESCRIPTION. Dual channel microwave scanner radiometer.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-3; 6-A/F-5; 6-G-1, -2, -3, -5, -6; 6-H-2; 6-H-5; 6-0-1, -2, -3; 6-0-5; 6-0-7; (Important) 6-A/F-1; 6-H-4

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A microwave scanner radiometer is required to measure surface temperatures from orbital altitudes. A multi-frequency dual polarization instrument is desirable. A trade-off exists between selection of a low frequency (10 ghz) with good weather penetration but poor resolution and higher frequencies (35 ghz) with poor weather penetration but good resolution. A dual frequency 10 and 19.35 ghz instrument appears to be best for geological, hydrological and oceanographic purposes. The fabrication of electronically scanned antennae in sizes larger than about 5 feet in size is a major problem. Large antenna must be folded when stowed, requiring structural joints which lead to antenna losses. Ground resolution requirements for the microwave radiometer are as follows.

Microwave Scanner Radiometer

Research Cluster	Ground Resolution (feet)	Research Cluster	Ground Resolution (feet)
6-A/F-1	50-200	6-H-2	6 nm
6-A/F-3	100-200	6-H-4	6 nm
6-A/F-5	200	6-H-5	6 nm
6-G-1	1-2 nm	6-0-1	300
6-G-2	1-2 nm	6-0-2	300
6-G-3	1-2 nm	6-0-3	300
6-G-4	6 nm	6-0-5	300
6-G-5	6 nm	6-0-7	1500
6-G-6	1-2 nm		

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A passive microwave radiometer operating at 19.35 ghz is under development for Nimbus E and is scheduled for flight in June 1972. Developed at NASA-GSFC, it will have at 1.4 degree resolution (6.5 nm on the ground from 235 nm altitude). Another passive microwave radiometer has been proposed for Skylab B. It operates at 5 ghz and has a 12 nm resolution over a 280 nm field from 235 nm altitude.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None, although research relating to the radar altimeter/scatterometer should benefit this development.

11. SUGGESTED DEVELOPMENT APPROACH(ES). The current 19.3 GHz radiometer development should continue unaltered and a parallel development to add second channel and dual polorization should begin.

12. SPECIAL FACILITIES REQUIRED. Microwave Test Facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NIMBUS E & F and NASA-GSFC and NASA-MSC aircraft tests.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Five Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. UHF Sferics Detector

2. BRIEF DESCRIPTION. Development of a UHF sferics detector.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-5; 6-M-2; 6-M-6

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An instrument is required to measure the field strength of UHF sferics. An additional goal is to be able to distinguish between lightning and nonlightning associated sferics. This instrument must be capable of measurement from orbital altitudes in order to determine global and synoptic distributions of thunderstorms and convection. Resolution on the order of 300 nm is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This instrument was originally proposed for AAP in April 1967 and is currently on the inactive list. The proposed system was to have a resolution of 50 degrees with the possibility of improvement to 20 degrees. This corresponds to 225 nm and 80 nm respectively from 235 nm altitude. Ground based equipment does exist but this would have to be adapted and qualified for space activities.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Adapt present ground based equipment for spaceflight or extension of proposed instrument.

12. SPECIAL FACILITIES REQUIRED. Special ground-truth sites will be required for aircraft and space testing.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. The Forest Service and Bureau of Land Management are field testing a lightning-detection sensor aboard an aircraft. The equipment can detect and track storm systems that produce the type of lightning that causes fires.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $700,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Data Collection System

2. BRIEF DESCRIPTION. Development of a ground station data collection and relay system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-2; 6-A/F-4, -5; 6-G-3; 6-H-1, -2; 6-H-6; 6-0-1, -2, -3, -4, -5, -6, -7; (Important) 6-H-3, -4, -5; 6-H-7

4. ITEM NO(S). Part II, No. 3, No. 4

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. In several experiment groups in the disciplines of Agriculture/Forestry, Geology, Hydrology and Oceanography, collection of data from surface-based sensing platforms by satellite is of extreme importance in achieving the objectives of the experiments. Development of sensing platforms with the capability of transmitting data to a satellite, and development of the satellite-borne components for relay of data to data acquisition stations is recommended. Typical data which would be collected are: water pollution - saline content, chemical pollution, radiological pollution; soil data - moisture content, soil temperature, acidity-alkalinity (PH), soil salinity; meteorological data - air temperature, relative humidity, wind velocity and direction, cloud cover, pressure, rainfall; flood control and snow inventory - precipitation (rain and snow), river stage, tidal stage, streamflow rate, snow depth, snow temperature, snowpack water content,

snowpack runoff; oceanographic data - wave profile, sea temperature, water vapor profile, surface oiliness, chemical pollution, suspended sediment, phytoplankton content; geological data - seismic activity, surface strain, surface tilt. Also to be developed is the data communication system on the surface platforms and spacecraft. This includes the data processing and encoding and the interrogation scheme. Up to 10,000 - 20,000 ground platforms may be required. See Appendix F for typical specifications.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Presently data from surface-based sensing platforms is collected by land-line communications or by field crews. Data collection by satellite will offer an economical means of collecting a large amount of hydrologic data rapidly on a national scale. A first-generation data collection system is flying on Nimbus 3. Called the Interrogation, Recording and Location System (IRLS), it is capable of locating and identifying transmissions from up to 12 remote surface platforms, receive and record the data, and relay the results to a ground station. A system of more extensive capability is planned for the ERTS program, where up to 1,000 ground stations will be involved.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Define the required extension in capability beyond the ERTS IRLS system; develop the surface sensors and communication system.

12. SPECIAL FACILITIES REQUIRED. None

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Data collection system currently under study by NASA, Goddard Space Flight Center, for ERTS A and B satellites.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT.
Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT.
$1 Million to $10 Million depending on complexity and number of surface stations.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT.
High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Star Tracking Telescope

2. BRIEF DESCRIPTION. Star tracking telescope for star occultation measurements.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-3

4. ITEM NO(S). Part II, No. 3

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An instrument is required that can track the motion of a star relative to the spacecraft as it is being occulted by the Earth. This will yield a measure of atmospheric density through analysis of the star light refraction. It must be done with a high degree of accuracy (.3 of a degree or better) in order to achieve accurate density soundings. A secondary purpose is to acquire background radiance measurements and starlight atmospheric attenuation. Acquisition and data-taking telescopes are required as well as azimuth and elevation gyroscopes.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A 150-inch Schmidt-Cassegrain telescope was proposed for AAP but this proposal is inactive. A double telescope image-dissecting phototube star-tracker ;with accuracy of .28 degrees x .28 degrees, low in weight and power requirements has been proposed by the U. of Michigan for Nimbus E. The instrument proposed is an automatic

star-tracker, consisting of a double telescope assembly and an image-dissecting phototube. Star tracker angular resolution is 1-4 sec of arc. The gimballed telescope assembly views the horizon in the orbital plane. Upon command the tracker scans across 60 degrees in azimuth and 8 degrees in elevation seeking a star exceeding a pre-set brightness. Upon finding such a star, it is tracked by a second telescope with a field of view of 17 arc-min by 17 arc-min, until occultation by the Earth. The apparent angular displacement, which is a measure of the refractivity, is then recorded. After occultation the process is repeated. The period of time for acquisition is 5 to 10 seconds, depending on location of bright stars. Tracking until occultation requires one to three minutes depending upon elevation of initial acquisition.

Reference: NASA-ERC Space Applications Instrument Survey, Project 160-44-05-28-25, 1970.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Adapt University of Michigan system for manned operation.

12. SPECIAL FACILITIES REQUIRED. Optical Instrumentation Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. University of Michigan Proposal for Nimbus E.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 31 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Zero-G Cloud Physics Chamber

2. BRIEF DESCRIPTION. Development of a chamber which would perform liquid droplet research in space.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-M-4

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Development of a cloud chamber, about 10 x 10 x 10 inches, suitable for manned orbital operation. Include provision for introduction of water droplets, as well as ice crystals of micron size and variability of temperature from 40°C to + 25°C, pressure from 0 to 15 psi, and electric field from 0 to 1000 volts/cm. Microscope and microphotography, both time-lapse and high speed are also required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Sophisticated chambers are available at University of Missouri, Rolla, Missouri, Colorado State University at Fort Collins, Colorado, UCLA at Los Angeles and at other locations. All were designed for terrestrial operations. None have flown in space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. STD EM-7 Zero-G Cloud Physics Laboratory

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of ground-based systems for orbital applications.

12. SPECIAL FACILITIES REQUIRED. A manned space satellite must be utilized.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. New concept by McDonnell Douglas Western Division.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Four Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $400,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

G

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Photo-Imaging Camera

2. BRIEF DESCRIPTION. Development of high resolution photo-imaging vidicon camera for near realtime data acquisition.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-5; 6-G-3; 6-H-2; (Important) 6-A/F-1, -2, -3, -4

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. In the experiment group of Flood Warning and Damage Assessment, the use of a photo-imaging camera (two-inch return-beam vidicon camera) has been specified for acquisition of imagery defining the areal extent of floodwater and assessement of damage. The primary value of this sensor is that imagery can be acquired and transmitted to data acquisition stations on a near-realtime basis. For a reconnaissance survey of flood damage, research cluster 6-H-2, resolution of 50 to 100 feet has been specified (Reference 1). To permit more precise assessment of flood damage, development of a television camera with higher resolution capability is proposed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. The two-inch return-beam vidicon camera currently under development for the ERTS A and B satellites will have a limiting, resolution of 4200 TV lines, or 300 ft. per optical line-pair from orbit. Field of view is 100 x 100 nm. A four and one-half inch return-beam vidicon camera has

been developed in experimental form at the RCA Electronic Components Division, Harrison, New York. Limiting resolution is 10,000 TV lines, corresponding to 120 ft/ optical line pair ground resolution with a ground coverage of 100 x 100 nmi.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Development of a space-qualified 4-1/2 inch return-beam vidicon camera based upon the present experimental camera design developed at RCA.

12. SPECIAL FACILITIES REQUIRED. Electro-Optics Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. RCA Research Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $20 Million, as follows:

	Year 1	Year 2	Year 3
Design	$2 Million	$2 Million	$ 500,000
Test	2 Million	4 Million	2 Million
Prototype Hardware	1 Million	3 Million	500,000
Flight Hardware		500,000	2.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

Reference 1: F. J. Wobber, "Environmental Studies Using Earth Orbital Photography," Photogrammetria, 24 (1969) pg 107-165.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. IR Interferometer Spectrometer

2. BRIEF DESCRIPTION. Evaluation of infrared interferometer spectrometer for meteorological and agricultural applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-2, -3, -4; 6-G-1, -2; 6-M-1; 6-M-6; (Important) 6-A/F-1; 6-A/F-5

4. ITEM NO(S). Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An infrared interferometer spectrometer operable from orbit is required. Wavelength range from 5 microns up to 50 microns is required. Ground resolution for meteorological research is on the order of 8 nm. In support of geological and agricultural research, the effects of the atmosphere to be measured by this instrument should be resolved on a scale comparable to the ground truth area. This requires a resolution capability on the order of 1 nm for most applications. This instrument should be capable of being trained onto surface target areas by the multispectral tracking telescope.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. IR interferometer spectrometers have been developed at Goddard Space Flight Center and are characterized as follows (all from 235 nm altitude):

Nimbus 3, 5-20μ, 8 deg. (33 nm) resolution
Nimbus D, 6.5-40μ, 5 deg. (20 nm) resolution
Nimbus E (proposed), 7.5-22μ, 2.3 deg (9.5 nm) resolution
Apollo Applications (proposed), S049, 5.0-22μ, 2.0 deg (8.8 nm) resolution.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of present designs or selection of an alternate measurement approach.

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Instrument Development at NASA-GSFC

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two to Three Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million to $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT
(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Multispectral Tracking Telescope

2. BRIEF DESCRIPTION. Surface-target tracking telescope capable of taking multispectral photographs.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2; 6-A/F-5; (Important) 6-A/F-3, -4

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A surface-target tracking telescope is required with a ground resolution on the order of 15 feet up to 100 feet. The instrument should be all-reflective for transmission in the thermal infrared. It should be compatible with the selective chopper radiometer (STD EI-16) and infrared filter wedge spectrometer (STD EI-17) so that these instruments can function through it for high-resolution operation. Simultaneous multispectral photography over six spectral bands is required.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An observation telescope system has been proposed for SKYLAB B. This instrument has a variable field of view 0.4° - 65° and adjustable resolution 2-14 sec. of arc. This corresponds to 15 to 100 feet ground resolution over 2 to 300 nm swath from 235 nm altitude. It is not known whether refractive optics are used.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of Proposed Skylab Instrument

12. SPECIAL FACILITIES REQUIRED. Optical Manufacture and Test Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Skylab B Instrument Proposal

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Four Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $8 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Infrared Selective Chopper Radiometer

2. BRIEF DESCRIPTION. Development of spaceborne laser chopper radiometer for meteorological and agricultural applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1; 6-A/F-4; 6-M-1; 6-M-6; (Important) 6-A/F-5

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Development of an infrared selective chopper radiometer to measure atmospheric temperature structure up to 50 km in altitude as well as surface soil temperature. Meteorological research requires a ground resolution on the order of 1 to 2 nm. In support of agricultural measurements, this instrument should be used through the collecting optics of the tracking telescope (STD EI-15) for ground resolution on the order of 100 feet. Spectral range should include 0.8 to 2.5 microns and 8 to 13 microns.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A selective chopper radiometer is on Nimbus IV (launched 8 April 1970). It uses six channels at the 15 micron CO_2 band to determine the three-dimensional structure of the Earth's atmosphere. A planned concept for Nimbus E includes 13 channels from 8 to 200 microns. Seven channels observe in the 15 micron CO_2 band, two channels sound the water vapor distribution and four channels are used to observe cirrus clouds. This system has a resolution of 0.6 degrees (2.5 nm ground resolution from 235 nm altitude).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extend wavelength band range of Nimbus instruments.

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Facility

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NIMBUS IV Results and NIMBUS E Plans

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 30 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Infrared Filter Wedge Spectrometer

2. BRIEF DESCRIPTION. Development of infrared selective chopper radiometer for meteorological and agricultural applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1; 6-A/F-3, -4, -5; 6-M-1; 6-M-6

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An infrared filter wedge spectrometer is required for orbital remote sensing in agriculture and meteorology. For meteorological research, ground resolution on the order of 3 nm or better is required. For agricultural work, resolution requirements on the order of 100 feet indicate the use of this instrument through the high resolution tracking telescope (STD EI-15). Meteorological applications require a spectral range of 1.5 to 16.0 microns. For agricultural work, spectral requirements include 0.3 to 0.4 microns, 0.4 to 2.5 microns, and 8 to 13 microns.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A filter wedge spectrometer was included on Nimbus IV launched 8 April 1970 and is working properly. Its spectral range is 1.2 to 2.4 microns and 3.2 to 6.4 microns. This instrument originated at NASA-GSFC and has a 3 degree resolution (12.5 nm from 235 nm altitude). Another instrument proposed for the Apollo Applications Program was to have a 2 degree resolution over 1.5 to 16.0 microns.

Experiment S191 of Skylab A included an instrument of 1.0 millirad, resolution (1400 feet from 235 nm) over 0.4 to 15.5 microns. This experiment has been deleted.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of Instrument Planned for Skylab A

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. NIMBUS IV and NASA-GSFC development work.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 24 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Infrared Temperature Sounder

2. BRIEF DESCRIPTION. Development of infrared temperature sounder for agricultural and meteorological experiments.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-1; 6-M-6; (Important) 6-A/F-5

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD REPORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An infrared temperature sounding spectrometer operable from orbit is required. In meteorological measurements, desired ground resolution is on the order of 8 nm. In support of wildfire detection and monitoring, a ground resolution approximating the scale of surface fires is required. This should be on the order of 1 nm or less. Spectral range of 3.5 to 6 microns is adequate.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. An infrared temperature sounding experiment S043, was proposed for Apollo Applications. The instrument proposed by Ohio State University had a resolution of 2.4 degrees (10 nm from 235 nm altitude) over a 12-degree field of view. Spectral range was 3.46-6.05 microns. The instrument was successfully tested in a balloon flight in 1968.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of previously proposed instrument or selection of an alternate measurement approach.

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million to $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Satellite Infrared Spectrometer

2. BRIEF DESCRIPTION. Development of infrared filter spectrometer for agricultural and meteorological applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-2; 6-M-1; 6-M-6; (Important) 6-A/F-1

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A satellite infrared spectrometer is required. For meteorological applications, ground resolution on the order of 40 nm is sufficient. For support of agricultural research, ground resolution on the order of the ground truth area scale is necessary. This indicates that a resolution of approximately 1 nm is warranted. A spectral range of 11 to 36 microns is desirable with a spectral resolution of 0.1 microns.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A satellite infrared spectrometer has flown on Nimbus 3. This instrument, developed at ESSA, had a 12-degree resolution (50 nm from 235 nm altitude) over 11.1 to 15.0 micron spectral range. An advanced instrument flown on Nimbus 4 had a 12.5-degree resolution over a spectral range of 11.1 to 36 microns. Both of these instruments have a spectral resolution of 0.6 percent.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of ESSA instrument or selection of an alternate measurement approach.

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. ESSA Instrument Development Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One to Two Years

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million to $2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

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EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Temperature Profile Radiometer

2. BRIEF DESCRIPTION. Development of infrared temperature profile radiometer for forestry and meteorological applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-M-1; 6-M-6; (Important) 6-A/F-5

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An infrared temperature profile radiometer is required to obtain temperature profiles in the atmosphere. For meteorological applications, ground resolution on the order of 9 nm is required. For support of wildfire measurements, a resolution on the order of 1 nm is desirable. A spectral range of 11 to 18.6 microns is adequate, with a spectral resolution of about 0.5 percent.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A medium-resolution infrared radiometer was flown on Nimbus 2. An outgrowth of this instrument was proposed by ESSA for Apollo Applications. This infrared temperature profile radiometer was to have a 6-degree angular resolution (25 nm ground resolution from 235 nm altitude) and covered the 11.1 to 18.6 micron spectral range with a resolution of 1 micron. Another version of this instrument is proposed for Nimbus E. This system has a 2.5-degree resolution (10 nm from 235 nm altitude) over the 11.0 to 22.0 micron range.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Improvement of the ESSA design or selection of an alternate measurement approach.

12. SPECIAL FACILITIES REQUIRED. Infrared Instrumentation Test Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Nimbus E Instrument Development by ESSA

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 40 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$2 Million to \$3 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Visible Wavelength Polarimeter

2. BRIEF DESCRIPTION. Development of a visible wavelength polarimeter for agricultural applications.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1; 6-A/F-3, -4

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An instrument is required to measure the polarization of the radiation emerging from the top of the atmosphere in the visible region of the spectrum. These data are needed to study the effects of the surface reflectance of the radiation emerging from the top of the atmosphere. This instrument should also have the capability of determining the vertical distribution of atmospheric aerosols. Four narrow spectral bands should be studied, centered at 3800A, 4400A, 5000A, and 5800A. In order to support agricultural measurements, a ground resolution on the order of the ground truth area, down to about 1 nm, is desirable.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. This instrument concept and development was initiated by H. Sekera, UCLA. A Phase C Study for AAP Experiment S046 utilizing this instrument by General Electric for UCLA was completed in January 1968. It defined the experiment preliminary design, specifications, management plans for the flight hardware phase of the program, and provided a mockup of the experiment. Instrument resolution is 3 degrees giving a ground resolution of 12 nm from 235 nm altitude. Field of view is 120 degrees (700 nm from 235 nm).

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of UCLA instrument or selection of an alternate measurement technique.

12. SPECIAL FACILITIES REQUIRED. Optical Instrumentation Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. UCLA instrument development work, if currently active.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 36 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$1 Million to \$2 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM
AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ultraviolet Imager/Spectrometer

2. BRIEF DESCRIPTION. Development of ultraviolet imager and spectrometer integrated into a single system.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4

4. ITEM NO. Part II, No. 3; Part III

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A determination is required of the discriminating ability of ultraviolet spectral reflectance and stimulated emissions, in studying and identifying agricultural surface features. Ground resolution on the order of 100 feet is required. Ultraviolet radiation in the 3000 to 4000Å range is of interest. The concept of such an instrument is a system consisting of an image-dissector scanning spectrometer and an integrating electronic-scan imaging system. This system will measure the intensity of emitted and reflected energy as a function of wavelength in selected parts of the ultraviolet and visible spectrum where prominent Fraunhofer lines are present.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Preliminary aircraft tests of this concept and system have been encouraging. A prototype is under development by Perkin-Elmer and is scheduled for flight testing in 1974. No instrument has been developed for use in space. An instrument was proposed for the Apollo Applications Program. It was to have 1 degree resolution corresponding to about 4 nm ground resolution from 235 nm. Wavelength band was 3500-4000Å.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Extension of aircraft instrument or selection of an alternate measurement technique.

12. SPECIAL FACILITIES REQUIRED. Electro-Optical Instrumentation Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Perkin-Elmer Development Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 48 Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $2. 5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. Medium

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Laser Altimeter

2. BRIEF DESCRIPTION. Development of spaceborne laser altimetry system for geological, hydrological, and oceanographic research.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (critical) 6-G-3; 6-G-5; 6-H-2; 6-H-7; (Important) 6-EP-1; 6-G-4; 6-G-6; 6-O-4

4. ITEM NO. Synopsis No. 5, 6-G-3; 6-G-5

TYPE OF STD EFFORT

5. ACTIVITIES. Development; Experiments in Space and Not in Space to Define Present Capabilities

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. An analysis of the optimum diameter of corner reflector arrays for the spaceborne altimeter is required. Data are needed to determine the pointing accuracy of the laser. The technology of continuous wave versus pulsed lasers requires review. Research is also needed on types of lasers most suitable for spacecraft use with particular emphasis on continuous wave CO_2 lasers. Altitude resolution requirements are on the order of 10 to 50 feet for geologic data. Commercial or governmental organizations would not need to be versed in the art of laser altimetry. They would emplace corner reflectors at sites of geological or hydrological significance. Altimetry data for their individual reflectors would be relayed to the specific user so that proprietary data would not be made available to competitors.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Laser altimetry units have been designed and six ordered under a $1.7 million NASA contract with RCA for lunar mapping.

They will be used in conjunction with a metric camera to measure the altitude of Apollo 16 during precision photographic surveys of the lunar surface. Altitude resolution of 2 meters is possible from 80 miles above the lunar surface. However, problems of atmospheric attenuation or hazards to ground personnel are present on the Earth and must be considered in developing a spacecraft laser system for Earth observations.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Emplace corner reflectors on a known geological structure such as the Kettleman Hills in California. After ascertaining that the level of laser radiation is not dangerous, scan by aircraft-borne laser.

12. SPECIAL FACILITIES REQUIRED. Evaluate atmospheric effects from orbital altitude. A field truck with corner reflector discs of varying diameters is required with a communications capability with overflight aircraft. Accurate surveys of known structures will be needed to calibrate aircraft-borne laser data.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. TRW has an ongoing program of laser positioning and pointing research.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. An experimental field program using an instrumented aircraft with capabilities of high and low altitude scanning together with a geological field crew, communications truck and corner reflector arrays could be carried out in two years. Development and space experiment: one to two years.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. For a one year period, the aircraft cost is estimated at \$55,000; truck instrumentation and truck \$25,000; laser \$85,000; corner reflectors \$25,000; air and ground crew \$200,000. Development of a spaceborne laser altimeter should cost about \$1 Million.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Ground Data Processing Center

2. BRIEF DESCRIPTION. Evaluate development of a ground data processing center for Earth observations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-3, -4, -5; 6-G-3; 6-H-1, H-2; 6-H-4, -5; 6-M-5; 6-O-1; 6-O-7; (Important) 6-A/F-1, -2; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2; 6-G-4, -5, -6; 6-H-3; 6-H-6, -7; 6-M-1, -2, -3, -4; 6-M-6; 6-O-2, -3, -4, -5, -6

4. ITEM NO(S). Section 5.5 of Data Management

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A ground data processing center is needed to fulfill the following major requirements: (1) Receipt of spacecraft electronic and photographic data including relay of data collected by 10,000 - 20,000 ground sensor platforms; (2) Processing and reproduction of photographic film; (3) Processing and photographic reconstruction of electronic data; (4) Dissemination of data to users within time constraints. Amounts and types of data, precision processing requirements, special handling of time-critical data, standardization of data formats, data dissemination procedures are to be defined in detail.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Data processing center for ERTS program (NASA-Goddard) presumed to be in existence by 1973. This system, currently under study and development, is expected to handle the data gathered by one

photo-imaging (RBV) camera and one multispectral line scanner (ERTS A-4 channels, ERTS B-5 channels) in addition to a ground data collection network of up to 1000 stations. Also in existence is an Earth resources data processing center for aircraft data at NASA-MSC.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. For data that is perishable, for example, processing time is critical; for data that is not perishable the rating is "Important".

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Study of Requirements for Automatic Data Transmission System

11. SUGGESTED DEVELOPMENT APPROACH(ES). Evolve this data handling capability from an expansion of the ERTS data processing center.

12. SPECIAL FACILITIES REQUIRED. Ground data processing facility including photographic processing equipment line-scan video reconstruction equipment, extensive computation capability, data storage facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Data processing center for ERTS program currently being defined. Planning for future growth at this time will result in efficient facility layout and maximum flexibility in meeting future requirements.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three years from definition study to facility completion to upgrade the ERTS data center.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $20 Million to 40 Million beyond the ERTS data center cost (approximately $20 Million).

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Automatic Data Transmission System

2. BRIEF DESCRIPTION. A study of the development of an automatic data transmission system, which would be available internationally at low cost.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-5; 6-G-3; 6-H-1, -2; 6-M-5; 6-O-1; 6-O-4; 6-O-7

4. ITEM NO(S). Part IV 1. 3, 2. 2; Part VII 103

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Automatic data transmission system available at low cost to various national and international agencies. Study to determine whether such a system for earth observations data should be implemented, and if so, what data should be involved and what modifications to existing facilities are required. This system should be examined as an alternate to the centralized data processing center for the dissemination of time critical data.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Existing network of Automatic Picture Transmission (APT) stations have been utilized for weather satellite data in the Tiros, ESSA, ATS, Nimbus and Improved Tiros (ITOS) programs.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Study of Ground Data Processing Center

11. SUGGESTED DEVELOPMENT APPROACH(ES). Upgrade current APT stations to handle more complex data.

12. SPECIAL FACILITIES REQUIRED. Ground data station.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Global Atmospheric Research Program.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 12 Months for Study; 3 Years (Post Study) for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 for Study; $6 Million for Development of Spacecraft Hardware

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Space Radiation Effects in Films

2. BRIEF DESCRIPTION. Evaluation of space radiation effects in photographic films.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2; 6-M-4, -5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; 1-BM-4; 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). Part VI, No. 61

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A firm understanding of the effects of space environmental radiations on photographic films is required. Films include aerial black and white and color films, black and white and color infrared films, ultraviolet films. Radiation effects to be determined include fogging density level, uniformity and microstructure, color tone and balance shifts, and effects on image interpretability. Environmental parameters to be varied include orbital paths, exposure time, shielding types and amounts and storage temperature. Special processing techniques and film modifications which mitigate radiation effects require evaluation. A continuously updated library of photographic film characteristics and their reactions to the space environment should be established as an experiment planning tool.

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8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A recent analysis* for the Skylab program is the most comprehensive test and evaluation program ever completed on the radiation and other environmental effects on photographic films. Seventeen black and white, color, infrared and ultraviolet films were analyzed. Certain specific films applicable to Earth Observations have not been analyzed. Evaluation of cryogenic storage for reducing radiation sensitivity has not been well tested. Criteria for acceptable levels of fogging have not been well established.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Temperature-Humidity Effects on Photographic Films

11. SUGGESTED DEVELOPMENT APPROACH(ES). Continued experimentation with films in man-made radiation environments. Space experimentation for verification of ground-based work and for long-term effects.

12. SPECIAL FACILITIES REQUIRED. Radiation simulators particularly proton accelerators. Cobalt-60 gamma irradiation facilities, e.g., MSC High Range Calibration Test Facility, Photo Processing Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Cited Skylab film radiation studies should be extended. Film samples could be stored at cryogenic temperatures and for long durations aboard Skylab, even when unoccupied, as in-orbit tests.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Ground-based radiation effects testing, 4 months.

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. Ground-based testing, $300,000.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

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*Skylab Program Payload Integration, Skylab Radiation Film Studies, June 30, 1970, ED-2002-1110, Martin Marietta Corp.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Temperature-Humidity Film Effects

2. BRIEF DESCRIPTION. An evaluation of the temperature-humidity effects on photographic film over extended periods of time.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2; 6-M-4, -5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; 1-BM-4; 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3

4. ITEM NO(S). Part VI, No. 61

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments not in space to define present capabilities.

6. OBJECTIVES. Component

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A firm understanding is required of the temperature-humidity environmental effects on photographic films over extended time periods. Films to be considered are serial black and white and color, black and white and color infrared, and ultraviolet. Effects to be determined include fogging density level, uniformity and microstructure, color tone and balance shifts, and effects on emulsion mechanical properties such as hardness and dimensional stability. Susceptibility to fungus growth is also of importance. Storage times up to 180 days should be considered, since this is a possible future orbital logistics period.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A recent analysis* for the Skylab program is the most comprehensive test and evaluation program ever completed on temperature-humidity effects on films specifically applicable to use in space. Seventeen black and white, color, infrared and ultraviolet films were tested in environments ranging from 20-90% relative humidity, and 35-120°F temperature for 28 days. One test environment was extended for 84 days. Tests evaluated latent image degradation.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Space Radiation Effects on Photographic Films

11. SUGGESTED DEVELOPMENT APPROACH(ES). Primary attention should be given to extending film storage tests to 90 and 180 days. Test exposed films to examine latent image degradation as well as unexposed films to determine sensitivity degradation.

12. SPECIAL FACILITIES REQUIRED. Photo Processing Laboratory

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Cited - Skylab Film Test Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Nine Months

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $500,000 to $1 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

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*Skylab Program Payload Integration; Corollary Experiment Film Environment Degradation Tests; Martin Marietta Corporation, ED-2002-1109, June 30, 1970.

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Photographic Film Storage Vault

2. BRIEF DESCRIPTION. Evaluation of the development of a storage vault for protection of film from environmental degradation before and after exposure.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4, -5; 6-E/P-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2; 6-M-4, -5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; (Important) 1-BM-4; 2-VB-1, -2, -3; 2-IN-1, -2, -3; 2-P/T-1, -2, -3; 2-PL-1, -2, -3; 4-P/C-1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11

4. ITEM NO(S). Part VI, No. 61

TYPE OF STD EFFORT

5. ACTIVITIES. Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A photographic film storage vault is required to protect film from environmental degradation before exposure and after exposure prior to processing. Film must be protected from space radiation, high temperature, high and low humidity, and vacuum. Detailed design specifications, especially for radiation shielding and temperature-humidity regimes must be defined prior to vault development. If cryogenic storage is employed as a means of radiation desensitization, a heating system will be required to return films to normal operating temperature prior to use. Investigation into optimum film vault materials may be necessary.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A film vault is being built for Skylab. It does not provide environmental protection beyond radiation shielding. The spacecraft environmental control system provides the temperature-humidity environment. This system weighs over 3000 pounds, highlighting the significance of firm design criteria to minimize vault weight penalty.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Space Radiation Effects on Photo-Films; Temperature-Humidity Effects on Photo-Films

11. SUGGESTED DEVELOPMENT APPROACH(ES). Define firm storage criteria by predecessor experimentation as above; vault design, fabrication, qualification test.

12. SPECIAL FACILITIES REQUIRED. Radiation Test Facility for Design Qualification.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Extension of Skylab film vault design after evaluation of flight performance.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $1 Million to $1.5 Million

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. EVA Instrument Maintenance

2. BRIEF DESCRIPTION. Maintenance of instrument optical components and electro-mechanical subsystems via EVA.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2, -3; 6-M-5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; 1-BR-1-1, -1-3, -2-2, -3, 1-MM-1

4. ITEM NO(S). Part IV, No. 1.6

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Instrumentation used in Earth observations will require periodic maintenance and repair. This will be required by various electronic subassemblies, detectors, mechanical subsystems and optical components. Depending upon the instrument accommodation requirements within the spacecraft, EVA may be required to carry out the above tasks. In the case of imaging instruments for example, whether their optical surfaces are exposed to space directly or look through transmissive windows, periodic cleaning of the exposed optics from spacecraft effluent deposits will probably require EVA. This and other maintenance and repair requirements need to be defined in detail. Instrument design techniques for ease of maintenance and repair, especially by EVA, need to be developed. Methods for cleaning optical surfaces in the extravehicular environment must be developed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. No electrical, mechanical, or optical subsystems have been serviced in space via EVA. No plans exist for Skylab A tests of these activities. Gemini XII astronaut Aldrin unsuccessfully attempted to clean the outer window of the spacecraft's closed-hatch during his EVA. This does not simulate the high quality abrasion-prone optical surfaces contained in optical instrumentation.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD REQUIREMENTS DESCRIBED IN THIS STUDY WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Antenna Deployment Via EVA

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study of serviceable instrument designs and extravehicular operations; underwater and zero-g aircraft tests; IVA and EVA tests on Skylab.

12. SPECIAL FACILITIES REQUIRED. Underwater neutral buoyance test facility (NASA MSFC - 75' dia. 40' deep, MDAC-WD - 30' diameter, 56' deep); zero-g aircraft flight test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Skylab could be used to intravehicularly simulate and evaluate extra-vehicular maintenance and repair techniques in zero-g. Sample smudged optical surfaces could be mounted in airlock module to test cleaning techniques in vacuum and zero-g without EVA.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 4 Months for Study; 3 Months for Non-Space Experimentation

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. \$200,000 for Study; \$75,000 for Non-Space Experimentation

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. EVA Antenna Deployment

2. BRIEF DESCRIPTION. Investigation of the deployment of large antennas via Extravehicular Activity.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4; 6-EP-2; 6-G-1, -2, -3, -4, -5, -6; 6-H-2, -3, -4; 6-H-7; 6-O-2; 6-O-4, -5, -6, -7; 1-BR-1-1; 1-MM-1; 5-N-1, -2; 5-P-1, -2, -3, -4; 5-TF-1, -2; 5-CS-1, -2; 5-NS-1, -2, -3, -4, -5

4. ITEM NO(S). Appendix F, Section V, 2.2, Instrument Reference 4 and 7

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space and not in space to define present capabilities

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. The radar imager, radar allimeter/scatterometer, and microwave scanner radiometer require antenna deployment via manned EVA as a contingency mode in the event of automatic deployment failure. Antenna dimensions typically may be 10 to 30 feet or more, depending on frequency and desired resolution. Detailed extravehicular operations and systems requirements must be defined in a study before ground, aircraft, or space experiments can be performed.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. No manned deployment of large folded structures via EVA has ever been attempted in space. Some studies have considered possible techniques for manned antenna deployment of various designs, but none have been of sufficient detail to really identify development requirements.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Instrument Maintenance Via EVA

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study of design requirements and operations to allow deployment via EVA; underwater, aircraft, and space evaluations of study results.

12. SPECIAL FACILITIES REQUIRED. Underwater neutral buoyancy test facility (NASA-MSFC - 75' diameter, 40' deep, MDAC-WD - 30' diameter, 56' deep); zero-g aircraft flight test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Skylab could be used to evaluate deployment mechanisms intravehicularly, and full antenna handling extravehicularly.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Four Months for Study; Three Months for Ground Experimentation

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $150,000 for Study; $75,000 for Ground Experimentation

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Earth Observations Crew Operations

2. BRIEF DESCRIPTION. Evaluation of Earth observations equipment utilized in manned operations.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2, -3, -4, -5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; 1-BR-1-3, -3; 1-MM-1

4. ITEM NO(S). Part IV

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Operations

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Earth observations equipment requires manned operations for effective utilization. Some of the operations called for include the following: initial set-up, preparation for operation (e. g., electronics, warm-up and infrared sensor chill-down), calibration, sequencing, position and time updating, data-taking operations, status monitoring, adjustments, data processing, securing from operation, maintenance, resupply and repair, These operations require detailed definition and analysis to determine crew support equipment, man-machine integration effects on instrument design, and appropriate degree of automation.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Metric and multispectral cameras-have been operated in space by man in the Apollo program. Multispectral photography will also be done in Skylab. No other Earth Observations instrumentation has been operated in space by man. No equipment has been maintained or repaired in space.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study to define specific operations requirements and effects on instrument design and crew support equipment; experiments to verify operational techniques and equipment design.

12. SPECIAL FACILITIES REQUIRED. Underwater zero-g simulation facility; aircraft zero-g simulation facility; space test facility.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Skylab could be employed to test manned operational techniques of mock equipment, determine maintenance and repair, criteria and verify use of crew support equipment such as tools and restraint systems.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 6 Months for Study; 4 Months for Non-Space Experiments

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $200,000 for Study; $100,000 for Non-Space Experiments

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Photographic Processing System

2. BRIEF DESCRIPTION. Evaluation of film developing system for analysis of time - critical photographic data and monitoring of photographic equipment onboard this spacecraft.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-G-3; 6-H-2; 6-H-4; 6-M-4, -5; 6-O-1; (Important) 6-A/F-1, -2, -3, -4, -5; 6-G/C-1; 6-G-1, -2; 6-G-4, -5, -6; 6-H-1, 6-H-3; 6-H-5, -6, -7; 6-O-3; 6-O-6; 1-BM-4

4. ITEM NO(S). Part IV, No. 1.1., 1.3, 2.2; Part VII, No. 103

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. A photographic film developing system is required to permit analysis of time-critical photographic data and monitoring of photo equipment operation onboard the spacecraft. Onboard processing also reduces the necessary space radiation shielding to that required for the duration of pre-processing storage only. Since the films under consideration range from black and white to color and color infrared, in various formats and in both negative and positive transparency materials, more than one processing system may be necessary. The choice of processing method and system design must give close consideration to efficient utilization of processing consumables, toxic and corrosive nature of chemicals, toxic fumes emitted during processing and the effect of weightlessness on uniform chemical distribution and agitation over film surfaces. A

study is required to define specific photo processing requirements, the applicability of "dry" processing methods such as Polaroid and Kodak Bimat, and techniques for doing wet processing in zero-g.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Polaroid processing has not been operated in weightlessness, but should be applicable. Image quality is adequate to check system operation but not generally suited for analysis. Kodak Bimat system was successfully employed in Lunar Orbiter program, although with some problems of uneven development. Currently it is applicable only to black and white films of sensitivity no greater than that of Plus-X. High speed emulsions have not been successfully developed due to their relatively large thickness and high silver content. One wet processing system is known to have operated successfully in space. This system uses capillary action to distribute processing fluids over the film in weightlessness.* It was developed for and successfully flown by the USAF in 1964. This system holds great promise for developing all types of films in the space environment.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. ES-10 Photo Interpretation System

11. SUGGESTED DEVELOPMENT APPROACH(ES). Study contract to identify requirement specifications, determine applicability of Polaroid, Bimat and other dry methods, and define wet processing concepts and trade-offs.

12. SPECIAL FACILITIES REQUIRED. Photographic system facility for Test and Development Work.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Polaroid development work at Polaroid Cambridge, Massachusetts; Bimat development work at Eastman Kodak, Rochester, New York; Capillary chamber processor development at Aeronutronics, Newport Beach, California.

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*The Capillary Chamber Process for Ultrarapid Negative Processing, K. H. Lohse, M. B. Skolnick, Phot. Sci. and Eng. Vol 5 No 3 May-June 1961, pp 149-153, K. H. Lohse Aeronutronic Div. Philco-Ford Corp., Newport Beach, California.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Six Months to One Year for Study; One to Two Years for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $100,000 to $200,000 for Study; $1 Million to $3 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

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EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT (STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Photographic Interpretation System

2. BRIEF DESCRIPTION. A study to determine the requirements for onboard photographic analysis and for development of the associated equipment.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-G-3; 6-H-2; 6-H-4; 6-M-4, -5; 6-O-1; 3-OW, -OB, -OS, -XR; (Important) 6-A/F-1, -2, -3, -4, -5; 6-G/C-1; 6-G-1, -2; 6-G-4, -5, -6; 6-H-1; 6-H-3; 6-H-5, -6, -7; 6-O-3; 6-O-6; 1-BM-4

4. ITEM NO(S). Part IV, No. 1.1., 1.3, 2.2; Part IV, No. 103

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Development

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Study to determine the requirements for onboard photographic analysis and development of the associated photographic interpretation equipment; onboard photographic analysis is called for when time-critical data is gathered or for monitoring instrument operation. Equipment requirements are not clearly defined, but probably include a transparency viewer with stereo microscope, a microdensitometer, an isodensitracer or image quantizer, and a color densitometer.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. A flying spot scanner was used in the Lunar Orbiter program to convert photographic data into an analog video signal such as would be done by a densitometer. No other photographic interpretation equipment has ever been space qualified.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Critical -- some required experimental results cannot be achieved without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. Space-Qualified Photographic Processing Equipment

11. SUGGESTED DEVELOPMENT APPROACH(ES). (1) Study to define detailed photographic interpretation requirements and equipment to fulfill these requirements; (2) development of space-qualified equipment.

12. SPECIAL FACILITIES REQUIRED. Photo-Optical Instrumentation Laboratory.

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. None

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. 4 Months for Study; 12 to 18 Months for Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000 to $100,000 for Study; $1 Million for Development

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Spacecraft Effluent Effects

2. BRIEF DESCRIPTION. Evaluation of the effects of spacecraft effluents on instrumentation and data quality.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). (Critical) 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2; 6-G/C-1; 6-G-1, -2, -3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1, -2, -3; 6-M-5, -6; 6-O-1, -2, -3, -4, -5, -6, -7; 3-OW, -OB, -OS, -XR; (Important) 3-LF; 5-CS-1

4. ITEM NO(S). 82

TYPE OF STD EFFORT

5. ACTIVITIES. Study; Experiments in space and not in space to define present capabilities.

6. OBJECTIVES. Theory; System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Knowledge is required of the effects over time of spacecraft effluents on exposed surfaces of instrumentation and the quality of experiment data. Spacecraft effluents include atmospheric gases emitted through outgassing and leakage, solid and liquid waste products emitted through overboard dumping, dust particles, and propulsion system exhaust residues emitted by either the attitude control or primary propulsion systems. The combined effects of these effluents on the physical integrity of exposed instrumentation surfaces, such as optical elements, thermal control coatings, and moving and fixed structural members must be determined. The degradation of experiment data in the form of loss of spatial resolution, differential spectral absorption, scattering or emission of radiation, and geometric distortion must be evaluated. Knowledge is required of the composition, spatial distribution, and dynamic behavior of effluent clouds from various sources.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Numerous ground simulations of rocket plume impingement effects on optical and thermal and structural surfaces have been done in vacuum chambers. Degradation of optical surfaces and thermal control coatings has been demonstrated. The reflected light from dust and ice particles surrounding spacecraft has been observed in both Gemini and Apollo flights; these have led to difficulties in star tracking. No attempts to evaluate effluent cloud dynamics or effects on experiment data have been made. beyond a theoretical level.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Ground vacuum chamber tests on rocket plume effects should be continued, including effects on data quality. Space Testing is required to eliminate 1-g effects on cloud dynamics and effluent deposition.

12. SPECIAL FACILITIES REQUIRED. Vacuum Chamber Laboratory; Space Test Facility

13. KNOWN ONGOING ACTIVITIES WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. MDAC on-going research on rocket plume effects; Skylab could be used to emit metered quantities of various effluents and measure cloud dynamics and effects on test surfaces.

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. Three to Six Months for Study; One to Two Years for Ground Testing; and One Year for Space Experiment on Skylab, Excluding Instrument Development

15. ESTIMATE OF COST OF ACHIEVING ADVANCEMENT. $50,000 to $100,000 for Study; $150,000 per Year for Ground Testing; and $200,000 to $500,000 for Space Experiment, Excluding Instrument Development, and Including Planning and Post-Flight Data Analysis.

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

EARTH ORBITAL EXPERIMENT PROGRAM AND REQUIREMENTS STUDY

SUPPORTING TECHNOLOGY DEVELOPMENT

(STD) REQUIREMENT DESCRIPTION

1. STD TITLE. Remote Data Degradation Effects

2. BRIEF DESCRIPTION. A study of atmospheric and background degradation of remotely sensed data.

SOURCE FROM WHICH THIS STD REQUIREMENT IS DERIVED

3. RESEARCH CLUSTER(S). 6-A/F-1, -2, -3, -4, -5; 6-EP-1, -2,; 6-G/C-1; 6-G-1; 6-G-3, -4, -5, -6; 6-H-1, -2, -3, -4, -5, -6, -7; 6-M-1; 6-M-5, -6; 6-O-1, -2, -3, -4, -5, -6, -7

4. ITEM NO(S). Synopsis No. 5, 6-A/F-5, 6-G-1

TYPE OF STD EFFORT

5. ACTIVITIES. Experiments, Not in space, to define present capabilities.

6. OBJECTIVES. System

DESCRIPTION OF TECHNOLOGICAL GAP

7. REQUIRED LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY OR OPERATIONAL CAPABILITY. Experimentation is required to determine the degradation of remotely sensed data caused by atmospheric absorption and scattering, as well as background noise. The spectral transfer function of the atmosphere is required including its dependence on humidity, sun angle and viewing angle. This data is needed to correlate the multispectral photography and radiometry taken above the atmosphere, with measurements taken by low-flying aircraft and surface stations. Background noise effects on microwave radiometry must also be assessed, especially for forest wildfire and oceanographic measurements. Special data processing procedures may evolve for compensation of these effects as a result of this work.

8. PRESENT LEVEL OF THEORETICAL UNDERSTANDING, TECHNOLOGY, OR OPERATIONAL CAPABILITY. Atmospheric attenuation and scattering has been studied theoretically and some experimental data is available. (e. g. Reference 1.) The extent of the effect on remote sensing data obtained entirely above the atmosphere remains to be fully determined.

PROGRAMMATIC ASPECTS

9. CRITICALITY RATING. Important -- some required experimental results will be degraded, unreliable, or costly without this advancement.

10. OTHER STD ITEMS WITH WHICH THIS STD REQUIREMENT COULD BE INTEGRATED. None

11. SUGGESTED DEVELOPMENT APPROACH(ES). Use high altitude aircraft flights over ground truth sites of known spectral characteristics. About 97% of the Earth's atmosphere is below 80,000 feet in altitude.

12. SPECIAL FACILITIES REQUIRED. Aircraft Flight Test Facility Photographic Laboratory

13. KNOWN ONGOING ACTIVITES WITH WHICH THIS STD ACTIVITY COULD BE INTEGRATED. Possibly the NASA-MSC Remote Sensing Program

14. ESTIMATE OF TIME SPAN TO ACHIEVE ADVANCEMENT. One Year

15. ESTIMATE OF COST OF ACHIEING ADVANCEMENT. $200,000

16. ESTIMATE OF CONFIDENCE IN ACHIEVING ADVANCEMENT. High

Reference 1. - Photographic Considerations for Aerospace, Itek Corporation, 1966