

## **Recommendations of the Space Science Board for Space Experiments: Letter Report**

Space Science Board, National Academy of Sciences,  
National Research Council

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NATIONAL ACADEMY OF SCIENCES  
SPACE SCIENCE BOARD  
2101 Constitution Avenue, N. W.  
Washington 25, D. C.

Memorandum Report, December 1, 1958

TO: Administrator, National Aeronautics & Space Administration  
Director, National Science Foundation  
Director, Advanced Research Projects Agency

FROM: Hugh Odishaw, Executive Director, Space Science Board

SUBJECT: Recommendation of the Space Science Board for Space  
Experiments

This document presents, in outline form, current recommendations of the Space Science Board. These recommendations are based on studies conducted by the appropriate committees of the Board during the summer and early fall of 1958. They were formally adopted by the Board at its meeting on October 24-25. The content of the recommendations is known to the principal federal agencies having responsibilities in space work (National Aeronautics & Space Administration, National Science Foundation, Advanced Research Projects Agency), by virtue of their participation in the meeting of the Board, while one of these agencies (NASA) received upon request a complete set of the proposals on November 4, 1958. The Board is continuing its studies and will submit further recommendations of its findings.

Insofar as possible, the Board has considered five implementation phases with respect to the experimental proposals:

Phase 1. Feasibility study.

Phase 2. Development of a bench model. (This includes the experimental demonstration of the principles using transistor circuitry and other critical components required in satellites and rockets. It may also include preliminary balloon flights to test the apparatus.)

Phase 3. Development of a flight prototype model. (This model uses flight type components or the physical equivalents and is ready for a design test program although it may not have the final configuration required for a specific satellite.)

Phase 4. Checkout, launching and coordination. (This includes flight package design and fabrication, test of flight packages, preparation for a launching, and participation by the experimenter in a launching to the extent required.)

Phase 5. Data reduction and analysis.

Wherever possible, the recommended agency and recommended experimenter are indicated. Supporting documents received from interested proposers are attached to provide more details of the proposed experiment where this material has been available to the Board. With respect to such proposals, the Board believes that the proprietary interests of the submitting scientists, whether with respect to unique concepts or instrumental apparatus, must be kept in mind as a matter of principle and statute.

## I. ASTRONOMY

### A. Solar Physics

1. Title: Solar Lyman-alpha Radiation Measurements  
Institution: U. S. Naval Research Laboratory  
Project Director: Herbert Friedman

Remarks: This experiment is essentially the same as that supported under IGY Project 32.8 and which is still unflown. Herbert Friedman of the Naval Research Laboratory and William A. Rense of Upper Air Laboratories, University of Colorado, are considered to be the two investigators most ready for immediate work in the investigation of solar ultraviolet and x-ray radiation.

Board Action: The Board recommends support of this experiment for phases 1 through 5. (See also item 2 below.)

Supporting Document: Paper, "The Lyman-alpha Experiment".

2. Title: A Solar Lyman-alpha Intensity Monitor  
Institution: Upper Air Laboratories, University of Colorado  
Project Director: William A. Rense

Board Action: The Board recommends support for phases 1 through 5. (See also "Remarks", item 1 above.)

Supporting Document: Letter dated July 9, 1958, from William A. Rense to Chairman, Space Science Board.

I. ASTRONOMY

3. Title: An Experiment for Mapping the Sun in the X-ray and Far UV Regions by Means of a Satellite  
Institution: U. S. Army Signal Research and Development Laboratory  
Project Director: W. G. Stroud

Remarks: The Board notes that Stroud has indicated a willingness to collaborate with Herbert Friedman of the U. S. Naval Research Laboratory in this experiment and that to a certain extent Stroud's qualifications are complementary to Friedman's.

Board Action: The Board recommends that Stroud be encouraged to collaborate with Friedman on this experiment.

Supporting Document: Proposal, titled as above.

B. Stellar Astronomy

1. Title: Proposed Study for a Satellite Telescope  
Institution: Princeton University Observatory  
Project Director: Lyman Spitzer

Board Action: The Board recommends support for phase 1 of this work and suggests that the National Science Foundation may be an appropriate source of support for the study phase of the program.

Supporting Document: Proposal, titled as above.

2. Title: Feasibility Studies of the Development and Operation of an Astronomical Telescope in a Satellite Orbit  
Institution: Smithsonian Astrophysical Observatory  
Project Director: Fred L. Whipple

Remarks: The Board recognizes the scientific importance of an orbiting astronomical telescope, as proposed by the Smithsonian-Harvard Observatories, for observing radiation in the far ultraviolet. There is further agreement on the general feasibility of this proposal and the preliminary plans for executing it. However, since the formal proposal on the project was not available for Board consideration, further action is deferred.

Board Action: The Board recommends phase 1 support.

Supporting Documents: Proposal, titled as above and supporting documentation entitled "Notes on the Development and Operation of an Astronomical Telescope in a Satellite Orbit".

## I. ASTRONOMY

### C. General

1. The Board reaffirms its recommendation that consideration be given to providing support as soon as possible, for the development of a flashing light system, suitably packaged, for incorporation in a geodetic or astronomical satellite and that a study of ground tracking facilities be concurrently made to determine their adequacy. (See letter of July 24, 1958, from Executive Director, Space Science Board for prior recommendation.)

## II. THEORY OF RELATIVITY

1. Title: Relativistic Clock Experiment  
Institutions: (1) National Bureau of Standards -  
Rubidium gas cell clock  
(2) Massachusetts Institute of Technology -  
Cesium beam clock  
Project Directors: (1) Peter Bender, National Bureau of  
Standards  
(2) Jerrold R. Zacharias, Massachusetts  
Institute of Technology

Remarks: Because of the fundamental scientific value of an experimental validation of the general theory of relativity, the Board recommends that a satellite clock experiment be carried out as soon as possible. The Board is advised that suitable launching vehicles will probably not be available before 1960, and therefore recommends the following program schedule:

- a. Completion of feasibility study (phase 1) on both the rubidium gas cell clock and the cesium beam clock (by the respective institutions) with definitive technical reports by May 1, 1959.
- b. Completion of three (3) flight prototype models of each type (phase 3) by December 31, 1959.

Board Action: The Board recommends immediate support to:

- (1) National Bureau of Standards, for phases 1 through 3.
- (2) Massachusetts Institute of Technology, for phases 1 through 3.

In addition to the two experiments above, the Board recommends that support also be provided to Peter Bender, National Bureau of Standards, for instituting a program with a qualified lamp manufacturer for the improvement of alkali vapor lamps for light pumping applications.

II. THEORY OF RELATIVITY

- Supporting Documents:
- a. Proposal from National Bureau of Standards
  - b. Proposal from the Massachusetts Institute of Technology and the National Radio Company
  - c. Minutes of the Special Ad Hoc Committee for the Consideration of the Relativistic Clock, October 7, 1958

III. IONOSPHERIC PHYSICS

1. Title: Satellite Ground-Based Ionospheric Measurements

Remarks: The Board recommends that the following IGY satellite ground-based ionospheric measurement programs be continued for an additional year in view of the observational opportunities which will probably be available during the period July 1, 1959 to June 30, 1960.

<u>IGY Project Number</u>	<u>Short Title</u>	<u>Institution</u>	<u>Project Director</u>	<u>Estimated Amount</u>
32.40	Radio Interferometry and Data Analysis	U. of Illinois	G. W. Swenson	\$ 66,000
32.41	Interferometer/Doppler Recording & Analysis	National Bureau of Standards	Ralph J. Slutz	121,500
32.42	Auroral Ionosphere Studies	U. of Alaska	C. Elvey	66,000
32.43	Electron Density & Propagation Locations	Stanford U.	O. G. Villard	70,400
32.44	Doppler Measurements from Spaced Locations	Penn State	A. H. Waynick	82,200
32.46	Absolute Signal Strength & Frequency Measurements	Linfield Research Institute	W. P. Dyke	31,600
32.47	True-Height Electron Density Profiles	National Bureau of Standards	Ralph J. Slutz	75,000
32.48	Polar Satellite Propagation Measurements	Geophysics Research Directorate, AFCRC	W. Pfister	<u>25,000</u>
TOTAL				\$537,700

Supporting Documents: These projects are described, respectively, in the attached IGY Earth Satellite Program documents.

### III. IONOSPHERIC PHYSICS

2. Title: Multifrequency Ionospheric Beacon Transmitter

Remarks: The Board strongly recommends that a multifrequency ionospheric beacon transmitter be included in an early flight package, preferably for a launching not later than June 1959, and endorses the following optimum characteristics as developed by the Working Group on Satellite Ionospheric Measurements of the IGY Technical Panel for the Earth Satellite Program:

Frequencies: Approximately 20, 40, 108, 400, 1000 Mcs, harmonically related.

Transmitter stability:  $1:10^7$

Minimum power: 100 milliwatts to 1 watt with a stability for field strength measurements of less than 1%.

Antenna: Linearly polarized along the spin axis.

Modulation: Amplitude modulation or pulse modulation keyed off for one second period every thirty seconds on 20 and 40 Mc.

Lifetime: One year (self-destruction feature to be included if possible).

Orbit:  $75^\circ$  preferred but  $51^\circ$  would be acceptable; a  $63^\circ$  orbit should be avoided.

Perigee: 150 to 200 miles.

Apogee: Consistent with one-year lifetime.

It is also recommended that consideration be given to the addition of a frequency close to 40 Mc, i.e. 38 Mc, to permit better studies of Faraday rotation effects.

3. Title: Direct Atmospheric Electric Measurements from Satellites

Institution: U. S. Naval Research Laboratory

Project Directors: R. E. Bourdeau and J. F. Clark

Remarks: This group has instrumented such an experiment in rockets and could draw on the experience of the NRL miniaturization group.

Board Action: The Board recommends immediate funding, phases 1 through 5, of this proposal.

Supporting Document: Proposal, titled as above.

### III. IONOSPHERIC PHYSICS

4. Title: Development of Modified Langmuir Probe  
Institution: U. S. Naval Research Laboratory  
Project Directors: C. A. Pearse and Willard H. Bennett

Board Action: The Board recommends support of this experiment through phase 2.

Supporting Document: Proposal, "Charge Density and Ionic Composition".

5. Title: Ion Density Probe  
Institution: Geophysics Research Directorate  
Project Director: Mrs. R. C. Sagalyn

Remarks: This experiment is based on a modification of the ion density probe in Sputnik III. The experimenter requires three or four months to complete her study of improvements on the USSR experiment, but this could be accelerated with additional funds.

Board Action: The Board recommends support through phase 2.

Supporting Document: Minutes of Second Meeting, Committee on Ionospheres of Earth and Planets, Space Science Board, October 20, 1958.

6. Title: VLF Pulse Experiment  
Institution: Stanford University/Stanford Research Institute  
Project Director: R. A. Helliwell

Remarks: This experiment involves development of a pulsed transmitter by which pulse signals are received from the ground and monitored in the satellite. The study would require two to three months.

Board Action: The Board recommends support for feasibility studies (phase 1).

Supporting Document: "Proposal for a Very Low Frequency Satellite Experiment".



### III. IONOSPHERIC PHYSICS

7. Title: VLF Continuous Wave Experiment  
Institution: Stanford Research Institute  
Project Director:

Remarks: This experiment embodies a CW transmitter experiment in which signal strength from a CW vlf station is measured on mutually perpendicular magnetic loop and electrical dipole antennas.

Board Action: The Board recommends support for a review in detail (phase 1) of scientific and engineering design problems.

Supporting Document: Preliminary Proposal from Stanford Research Institute (par. 4).

8. Title: Topside Ionospheric Sounder  
Institution: National Bureau of Standards, Central Radio Propagation Laboratory, Boulder, Colorado  
Project Director:

Board Action: The Board recommends support for a study (phase 1) to determine feasibility and design requirements.

Supporting Document: Minutes of Second Meeting, Committee on Ionospheres of Earth and Planets, Space Science Board, October 20, 1958.

### IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

#### A. Magnetic Fields

1. Title: Magnetic Field Studies From an Earth to Moon Package and a Polar Orbit Earth Satellite  
Institution: U. S. Naval Research Laboratory  
Project Directors: J. P. Heppner and L. E. Meredith (with Varian Associates)

Remarks: Instrumental development includes light-pumping alkali vapor magnetometer (scalar) having approximately  $10^{-5}$  gauss sensitivity. This is for use in studies within 2 earth radii, fringe or transition fields as functions of time and position (3 - 20 earth radii), interplanetary fields (solar connective field) as functions of time, and lunar field.

Board Action: The Board recommends support for phases 1 through 5.

Supporting Document: Proposal, titled as above.

IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

2. Title: Search for Hydromagnetic Waves Above the Ionosphere.

Institution: Lockheed Aircraft Corp., Missile Systems Division

Project Directors: Francis S. Johnson and A. J. Dessler

Remarks: Project involves no significant instrument development

Board Action: The Board recommends support for phases 1 through 5.

Supporting Document: Lockheed document LMSD-5134, Section 1.

3. Title: Mapping of the External Geomagnetic Field from Satellites

Institution: University of New Mexico

Project Director: V. H. Regener

Remarks: This proposal involves the development of instrumentation and its use in studies of fringe or transition fields as function of time and position.

Board Action: The Board recommends support through phase 2.

Supporting Document: Proposal, titled as above.

4. Title: High Altitude Studies of the Earth's Magnetic Field

Institution: State University of Iowa

Project Director: L. J. Cahill, Jr.

Remarks: Involved here are studies within 2 earth radii and studies of fringe or transition fields as function of time and position at greater altitudes.

Board Action: The Board recommends support for phases 1 through 5 with the advice that the simplest possible equipment should be used for immediate exploration.

Supporting Document: Memorandum for Space Science Board from the State University of Iowa dated July 12, 1958, p. 14.

IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

5. Title: Development of Minimum Weight Prototype Instrumentation for Geomagnetic Measurements with Earth Satellites  
Institution: Smithsonian Astrophysical Observatory collaborating with Batelle Memorial Institute and Harvard College Observatory  
Project Director: Fred L. Whipple, Smithsonian Astrophysical Observatory

Remarks: This proposal involves a vector magnetometer utilizing the Hall effect in a semi-conductor, with a vector sensitivity approaching  $10^{-4}$  gauss. This development appears desirable because of light weight, simplicity, and possibility of future improvement.

Board Action: The Board recommends support through phase 2.

Supporting Document: Proposal, titled as above.

General

1. With regard to basic instrumentation requirements for the measurement of magnetic fields, the Board recommends immediate support for the development of magnetometers to the following specifications:
  - (a) scalar (light pumping), of sensitivity  $10^{-5}$  gauss and sampling time a few seconds.
  - (b) vector, of sensitivity  $10^{-4}$  gauss, angular precision  $2^{\circ}$  -  $5^{\circ}$  at  $10^{-4}$  gauss level. Here, improved semi-conductor magnetometers offer promise. The possibility is suggested that MAD unit or Navy 3-component pendulum unit may be improved to approach these specifications.
  - (c) There is need for an extremely simple instrument suitable for routine use in rockets and satellites for exploratory purposes. Here, small size and weight, simplicity of operation, and sensitivity are most important.
2. An extended period of geomagnetic field observations should be initiated as soon as possible, 1959 at the latest, in order to take advantage of observational possibilities during the post maximum period of the solar cycle. These observations should continue for a year or more.

IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

B. Low Energy Particle Radiation ( $< 100$  Mev)

1. Title: Low Energy Particle Studies  
Institution: State University of Iowa  
Project Director: J. A. Van Allen

Remarks: These studies are aimed at the mapping of low energy particle density and spectrum with pole to pole orbits; and for particle identification, which is considered to be of greatest immediate importance (search for protons, electrons,  $He^{++}$ , etc.)

Board Action: The Board recommends support for phases 1 through 5.

Supporting Document: Memorandum for Space Science Board from State University of Iowa dated July 12, 1958.

2. Title: Satellite Auroral Particle Measurements  
Institution: U. S. Naval Research Laboratory  
Project Director: L. R. Davis and L. H. Meredith

Board Action: The Board recommends support for phases 1 through 5.

Supporting Document: Proposal, titled as above.

C. Cosmic Rays

1. Title: Cosmic Ray Investigations  
Institutions: Bartol Research Foundation and  
Rias, Inc., Division of The Martin Company  
Project Directors: Martin A. Pomerantz - Bartol  
Gerhart Groetzinger - Rias, Inc.

Board Action: The Board recommends support through phase 2 for the following experiments:

- (a) composition, intensity and variations with time of relativistic particle energies
- (b) exploratory studies of particles with atomic number greater than 6.
- (c) searches for  $\pm$  electrons.

Supporting Documents: Proposal from Bartol dated July 11, 1958; Letter from Gerhart Groetzinger to Chairman, Space Science Board, dated July 11, 1958.

IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

2. Title: Studies Concerning Relativistic and Nonrelativistic Particle Energies  
Institution: State University of Iowa  
Project Director: J. A. Van Allen

Remarks: Involved here are studies in composition, intensity, and variations with time of relativistic and nonrelativistic particle energies.

Board Action: The Board recommends support through phase 3.

Supporting Document: Memorandum for Space Science Board from State University of Iowa dated July 12, 1958.

3. Title: Satellite-Borne Cosmic-Ray Experiments  
Institution: The University of Chicago  
Project Director: J. A. Simpson

Board Action:

1. The Board recommends support through phase 3 for those portions of the proposal dealing with:

(a) studies in composition, intensity, and variations with time of relativistic and nonrelativistic particle energies

(b) experiments in the use of cosmic rays as probes of geomagnetic field, solar and interplanetary magnetic fields.

2. The Board recommends support through phase 2 for that portion of the proposal on the search for  $\pm$  electrons.

Supporting Document: University of Chicago documents CML-PR-E-1150 and 127.

4. Title: High-Energy Gamma-Ray Satellite-Borne Experiment  
Institution: Massachusetts Institute of Technology, Laboratory for Nuclear Science  
Project Director: W. Kraushaar

Board Action: The Board recommends support through phase 2.

Supporting Document: Proposal, titled as above.

IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

5. Title: A Proposal for the Measurement of Cosmic Light and Radiation From an Earth Satellite  
Institution: California Institute of Technology, Jet Propulsion Laboratory  
Project Director: H. Victor Ncher, for cosmic-ray portion

Board Action: The Board recommends support for phases 1 through 5 for the cosmic-ray portion of the experiment.

Supporting Document: JPL Publication No. 70 attached.

6. Title: Proposal to Explore the Properties of High Energy Radiation at Rocket Altitudes  
Institution: University of Chicago  
Project Director: Marcel Schein

Remarks: This proposal has already been endorsed by the Space Science Board and presumably has been included in the Department of Defense Program by the Geophysics Research Directorate.

Board Action:

1. The Board recommends support through phase 3 for experiments with recoverable emulsion blocks carried in rocket nose cones.
2. The Board recommends support through phase 2 for experimental searches for magnetic monopoles.

Supporting Document: Proposal, titled as above.

D. General

1. Title: Observation of x-rays ( $\geq 0.5$  Mev.)
  - a. Map of celestial sphere in the light of x-rays
  - b. Image of sun and solar flares
  - c. X-rays of terrestrial origin
  - d. Spectral distribution

Remarks: Adequate instrumentation appears to be available. Attitude control and registration appear to be required.

Board Action: The Board recommends that proposals be solicited.

#### IV. PHYSICS OF FIELDS AND PARTICLES IN SPACE

2. Title: Special Aurora and Airglow Observations
  - a. Pictures of Earth in the  $\lambda$  5577A and  $\lambda$  3914A Bands
  - b. Associated low energy detectors on vehicles with experiment
  - c. Associated magnetometers
  - d. Far ultraviolet exploration of auroral distributions

Remarks: To meet the instrumentation requirements for image registration and transmission, improvements may be needed in attitude control and registration, photoelectric devices, image storage, and wider band telemetry.

Board Action: The Board recommends that proposals be solicited.

3. Title: Detection of Interplanetary Particles: 0 to 50 kev Ions, Electrons, Neutral Atoms, and Molecules, etc. as follows:
  - a. Energy spectrum
  - b. Ratio of neutral to charged
  - c. Composition
  - d. Directional detection
  - e. Time dependence
  - f. Associated magnetic fields
  - g. Plasma experiments ( < 100 ev particles)
  - h. Search for free radicals in space

Remarks: These measurements will require development of new kinds of detectors supported by improvements in attitude registration, electron-multiplier development, and radio probe methods.

Board Action: Proposals should be solicited and interest stimulated in measurements of this type.

## V. METEOROLOGY

1. Title: Investigation of Thermal Radiation Budget of the Earth and Survey of World-Wide Thunderstorm Activity Using an Earth Satellite

Institution: University of Wisconsin

Project Director: V. E. Suomi

Remarks: The Board recommended to the Government on July 24, 1958, that support be given to the development of equipment for a directional bolometer experiment designed to make measurements of global radiant energy. Details for this bolometer are given in Section IV of the enclosed proposal.

Board Action: The Board recommends immediate support for the following experiments:

Improved Radiation Balance Experiment, Phases 1 through 5, (Section II)

Improved Meteorological Experiments, Phases 1 through 5, (Section III)

Experiment Using Directional Bolometers, Phases 1 through 5, (Section IV)

Radiation - Cloud Cover (combination experiment), Phases 1 through 5, (Section V)

World-Wide Thunderstorm Survey, Phase 1, (Section VI )

Supporting Document: Proposal, titled as above.

## VI. INTERPLANETARY PROBES AND SPACE STATIONS

In order to develop a Board position with regard to interplanetary probes, considerable study was given to the general consideration of the problem and to two proposals, one for a Venus probe and one for a Mars probe. The Board did not consider these last proposals per se but used, as the basis for formulating its recommendation, the general recommendations which were transmitted to the Government by our letter of October 3, 1958, summarized herewith as follows:

1. It is urgently necessary to begin the exploration of space within the solar system with any means at our disposal if a continuing U. S. program of space science and exploration is to proceed at an optimum rate. To this end, a comprehensive program of deep space probes should be initiated.



VI. INTERPLANETARY PROBES AND SPACE STATIONS

2. With vehicles of the Thor-Able it appears possible to get a payload of the order of 50 lbs. out to interplanetary distances in the fairly near future, while maintaining communication and control. As far as the Thor is concerned, it is recommended that it be used without a control retro rocket as part of the payload and that the additional weight thereby made available be used to increase the reliability of communications, and perhaps for additional experiments.
3. It is recommended that a program aimed at launching a Mars probe during the 1961 conjunction be immediately initiated.
4. With a combination such as Atlas and a high performance second stage, a payload in excess of 1,000 lbs. seems feasible. It is therefore recommended that immediate steps be taken to begin the development of a space vehicle based on the Atlas plus a high performance second stage, together with suitable communications and controls, in order to provide a payload sufficient to carry out a more scientifically satisfying set of experiments on the planets Venus and Mars. In addition, because of the long lead time involved in such a program, development of vehicle telemetry and experimental equipment should be started soon.
5. A study of appropriate scientific packages for different classes of space probes is now in progress. Recommendations resulting from this study will be provided to the Government shortly after the first of the year.
6. With regard to manned-space stations, the Board feels that further study is required before specific recommendations can be provided.

Supporting Document: Minutes of the Ad Hoc Committee on Interplanetary Probes and Space Stations, September 13, 1958.