DEPARTMENT OF THE AIR FORCE
11TH WING

7 November 2000

11 CS/SCS (FOIA)
[redacted]

Mr. John Greenewald, Jr.
8512 Newcastle Avenue
Northridge CA 91325

Dear Mr. Greenewald

This is in response to your 14 August 2000, Freedom of Information Act (FOIA) request for a copy of the document "A White Paper on the Accomplishments of the DoD Space Test Program, 1967-1976." We received your request on 6 October 2000.

In this instance, we are unable to meet the time limits imposed by the FOIA. We need additional time to search for the records you requested.

Please be assured that your request is being processed as quickly as possible.

If you have any questions, please contact the Ms. Virginia Broadnax at (703) 696-7268 and refer to case # 01-0023.

Sincerely

RHONDA M. JENKINS
Chief, Documentation Information
and Services Branch

DEPARTMENT OF THE AIR FORCE
WASHINGTON DC

OFFICE OF THE ASSISTANT SECRETARY

FEB 6 2001

SAF/AQ
1060 Air Force Pentagon
Washington DC 20330-1060

John Greenewald Jr
[redacted]

Dear Mr. Greenewald

This letter responds to your request under the Freedom of Information Act (FOIA) for document AD B020801, A White Paper on the Accomplishments of the DoD Space Test Program, 1967-1976, dated August 1977 (case 01-0023).

To satisfy your request, our action officers reviewed all material maintained locally by the Directorate of Space and Nuclear Deterrence (SAF/AQS). Because some of the documents contained material that was not releasable, we excluded that material, and prepared the remainder for release to you. Material that has not been included for this FOIA request falls under the following exemptions:

1. 5 USC 552 (b)(1) reference (a) relating to classified material and material that when combined with other material, discloses classified information. All classified information removed from the document was currently and appropriately classified.

2. 5 USC 552 (b)(3) reference (a) relating to material not subject to release by statute. The statute covering this material is 10 USC 130, Authority to Withhold Unclassified Technical Data with Military or Space Application.

3. 5 USC 552 (b)(6) relating to personnel information.

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Secretary of the Air Force
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1000 Air Force Pentagon
Washington DC 20330-1000

Sincerely

Darleen A Druyun

DARLEEN A. DRUYUN
Principal Deputy Assistant Secretary
(Acquisition & Management)

Attachment:
1. Requested record

DEFENSE DIVISION NOTE

DDN 77-3

A WHITE PAPER ON THE ACCOMPLISHMENTS OF THE DOD SPACE TEST PROGRAM—1967-1976

August 1977

[redacted] Project Leader

(b) (6)

Approved by
[redacted] Division Manager

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ACKNOWLEDGMENTS

We wish to express our appreciation to [redacted] of SAMSO/YAT and to [redacted] of Aerospace Corporation for their assistance in this study. (b)(6)

PREFACE

This White Paper is a result of an 8-week study of the contributions of the DOD Space Test Program from 1967 to 1976. The purpose of the study was to identify the benefits the Department of Defense accrued from the experiments supported by the Space Test Program. Due to limited time and the vast amount of data, we assessed the military benefits of the experiments mainly through conversations with the principal investigators and/or other knowledgeable individuals and with the personnel from the Space Test Program Office and the Aerospace Corporation. In all, we talked to more than 106 individuals and gathered varying degrees of information on 96 out of 98 experiments.

We assessed only the benefits derived from the experiments and did not evaluate any programmatic, procedural, or organizational matters of the program; nor did we examine any trends in the philosophy of the Space Test Program.

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INTRODUCTION

After Sputnik ushered in the era of space in 1957, the national space program devoted most of its efforts to the exploration of outer space. During the 1960s both the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD) were investigating the space environment, while space systems technology continued to develop at a rapid pace. Soon, space systems began to demonstrate new capabilities, and it became apparent that space systems could be immensely useful to the DOD. However, before developing and deploying space systems for operational use, the systems needed to be tested in space. In the 1960s, no adequate organization and funds were readily available to provide timely spaceflights for military space systems. Thus, in 1966, a DOD-wide Space Test Program was established to provide spaceflights to the military systems and investigate the space environment.

By 1969, man had landed on the Moon, and the near-Earth space began to be populated with a multitude of space systems performing a variety of functions. Now, space systems have become indispensable to DOD, providing such critical support to its forces as communications, navigation, surveillance, warning, and weather prediction. However, much systems testing and space research still needs to be done to develop more capable, reliable, and survivable space systems. By providing the necessary spaceflight support, the Space Test Program, therefore, has been playing a vital role in the development of military space systems.

SPACE TEST PROGRAM

The Space Test Program (STP), originally called the Space Experiment Support Program, was established by a memorandum dated 15 July 1966 from the Director of Defense Research and Engineering (DDR&E) to the Assistant Secretary of the Air Force for Research and Development. The memorandum designated the Air Force as the executive agent of the program, and the Space Test Program Office was established at the Space and Missile System Organization (SAMSO) to execute the Space Test Program.

The objective of the Space Test Program is to provide timely spaceflights for the DOD research and development payloads and certain operational payloads that are not authorized their own means of flight but demonstrate the potential to provide data to improve military space systems. The program provides its own spaceflights for the so-called primary payloads and arranges for space for the so-called secondary payloads on other DOD or NASA flights. The STP support for primary payload flights includes centralized management and funds for the launch vehicles, launch services, spacecraft, payload integration, and orbital support.

Until 1969, with an annual budget of $2 million, the primary function of the Space Test Program was to integrate experiments into spacecraft acquired by the other DOD agencies or by NASA. However, beginning in 1969, the STP began launching its own primary flights. This increased responsibility caused the manpower and technical support of the program to increase by a factor of about 10 and the average budget to increase from $2 million to $16 million by 1975.

SPACE TEST PROGRAM FLIGHT HISTORY

Since the first STP flight on 29 June 1967, more than 394 experiments* were proposed for spaceflight under the Space Test Program. These experiments have been sponsored by the following six Government agencies: the U.S. Army, the U.S. Navy, the U.S. Air Force, the National Security Agency (NSA), the Defense Advanced Research Projects Agency (DARPA), and the Defense Nuclear Agency (DNA).† The experiments were selected and ranked for flight according to their flight urgency, mission relevance, and program importance.

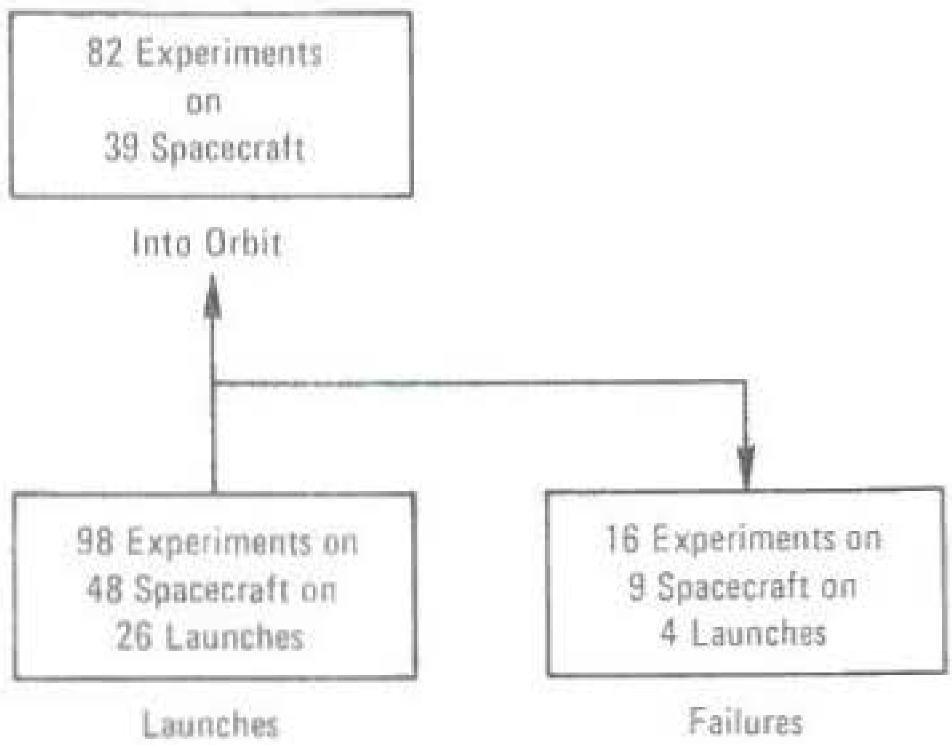
As of December 1976, 98 of these experiments have been launched on 26 flights, of which 12 were primary flights and 14 were secondary flights. Of the 98 experiments, 8 were sponsored by the Army, 17 by the Navy, 67 by the Air Force, 1 by the NSA, 3 by the DARPA, and 2 by the DNA.

Figure 1 shows the launch record of the STP flights. Twenty-two of the 26 launches—10 primary and 12 secondary—successfully placed 39 satellites containing 82 experiments in orbit. The number of experiments is subjective because it depends upon whether one counts the multiple purposes of the same experiment package as separate experiments or as a

*The term "experiment" here refers to both space environment measurements and space system or subsystem tests. Payload is defined as one or more satellites each containing one or more experiments.

†Formerly the Defense Atomic Support Agency (DASA).

FIGURE 1
SPACE TEST PROGRAM LAUNCH RECORD



single experiment. In this paper we counted a multiple-purpose experiment as one experiment.

Figure 2 shows the STP launch schedule from 1967 through 1976, and Figure 3 shows the STP cost history of each STP flight. Experiment costs funded by the sponsoring agencies are not included. In the flight designation numbers, the first letter "P" or "S" indicates whether the flight was a primary or a secondary flight, the following two digits indicate the year in which the launch was planned, and the last digit indicates the number of the flight in a particular year. In general, primary flights are more expensive than secondary flights because launch vehicle purchases are required. Early primary launches P67-1, P67-2, and P69-1 were exceptions because donated launch vehicles were used. Other primary flight costs reflect the acquisition costs of the various launch vehicles. The secondary flight costs are low because only integration and orbital support are included. The exceptions are S73-5, S73-6, and S74-2, which entailed the construction of three peculiarly shaped spacecraft.

ACCOMPLISHMENTS AND CONTRIBUTIONS OF THE STP EXPERIMENTS

The 82 experiments orbited successfully on 39 satellites by the Space Test Program can be classified into two distinct categories: (1) primarily system/subsystem and related tests (18 experiments) and (2) primarily space environment measurements (64 experiments). These categories can be divided further into several fields. Figure 4 shows the distribution of the number of experiments in each field, and Figure 5 shows the distribution of the orbital inclinations of the satellites and the regions of space that were investigated by the experiments. Of the 39 satellites, 25 were placed in high-inclination orbits,

FIGURE 2
SPACE TEST PROGRAM LAUNCH SCHEDULE

No.	Space Flight Number	Booster/Upper Stage	Payloads	Experiments
1	P67-1	THOR/BURNER II	2	2
2	S67-3	THORAD/AGENA	1	2
3	S68-2	NASA THORAD/AGENA	1	1
4	P68-1	ATLAS/BURNER II	6	10
5	P67-2	TITAN IIIC	4	14
6	P69-1	ATLAS F/TRI OV1	4	11
7	S69-2	NASA THORAD/AGENA	1	1
8	S68-3	TITAN IIIC	3	3
9	S69-4	THORAD/AGENA	2	1
10	S70-3	NASA THORAD/AGENA	1	1
11	S70-4	THOR/BURNER II	3	1
12	P70-1	LONG TANK THORAD/AGENA	1	2
13	P70-2	ATLAS F/DUAL OV1	2	9
14	P71-2	THORAD/AGENA	1	4
15	S71-3	THORAD/AGENA	1	2
16	S71-5	THORAD/AGENA	1	2
17	P72-1	ATLAS F/BURNER II	2	5
18	S73-7	LPC-509	1	1
19	P73-3	ATLAS F/2 SOLIDS	1	1
20	S73-5	TE-M-479	1	3
21	P72-2	ATLAS F	1	4
22	S75-1	----	1	1
23	S73-6	TE-M-516	1	7
24	P74-1	TITAN IIIC	4	2
25	S74-2	TE-M-521	1	7
26	P76-5	SCOUT	1	1

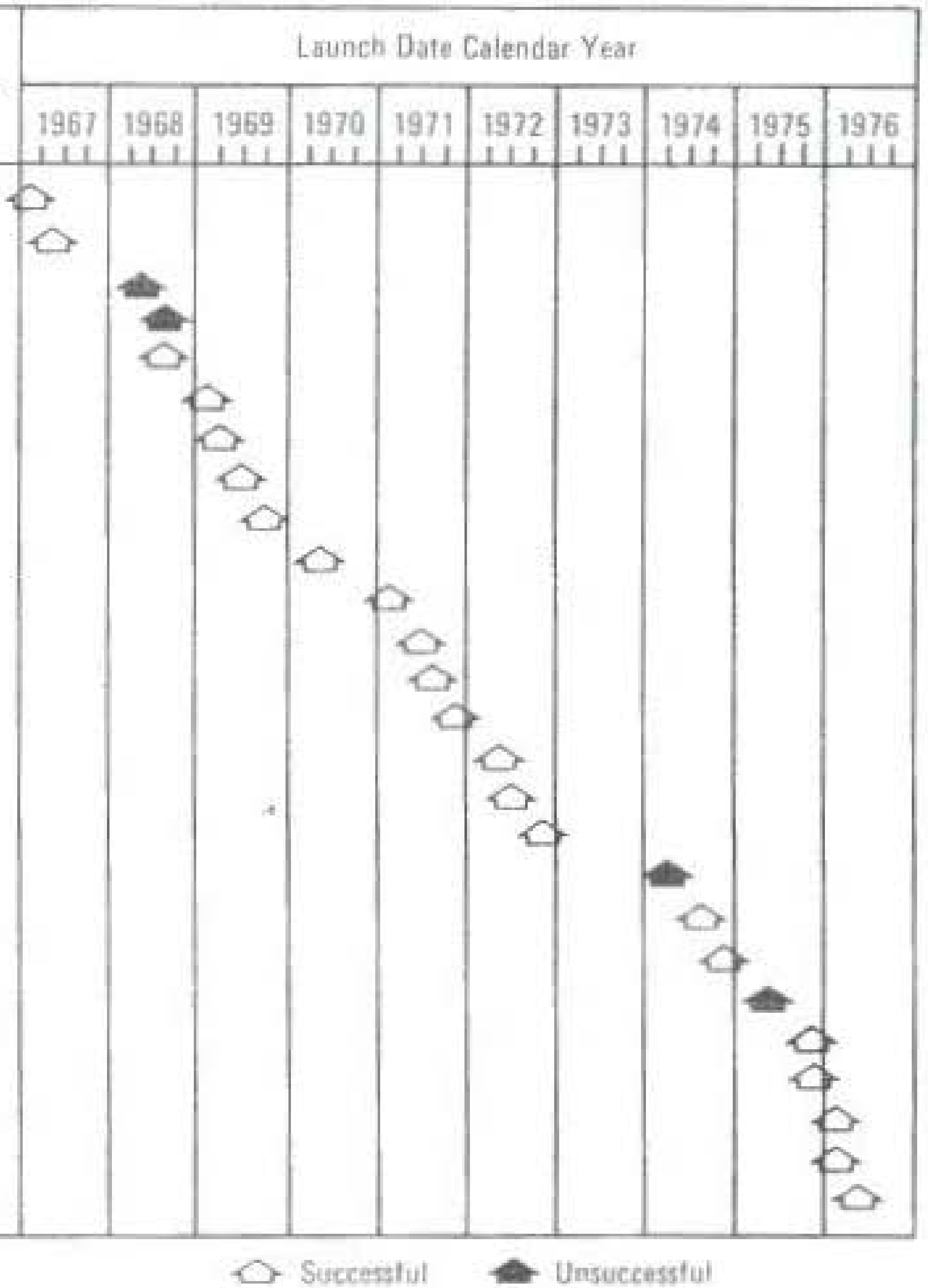


FIGURE 3
STP FUNDING BREAKDOWN

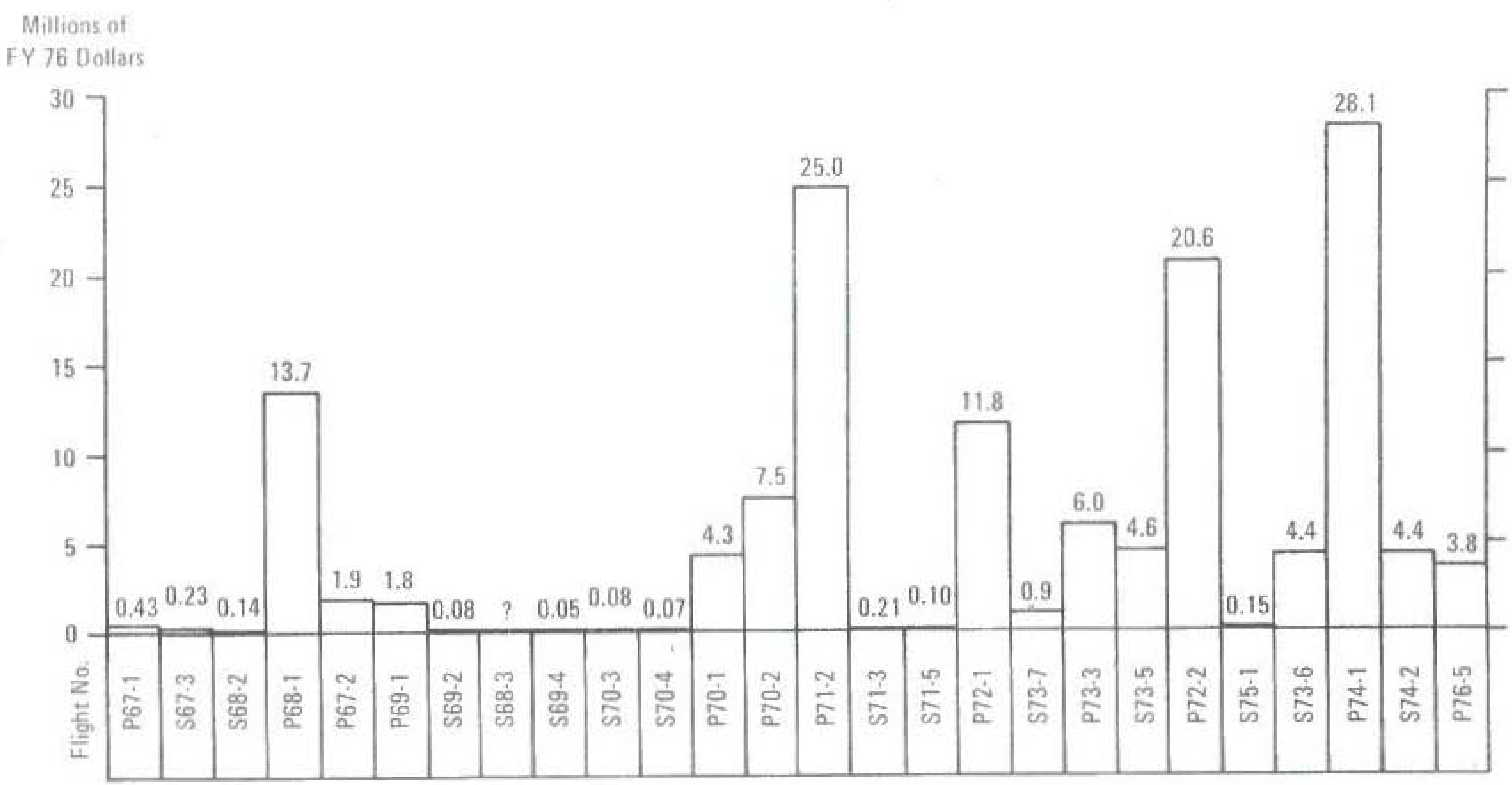
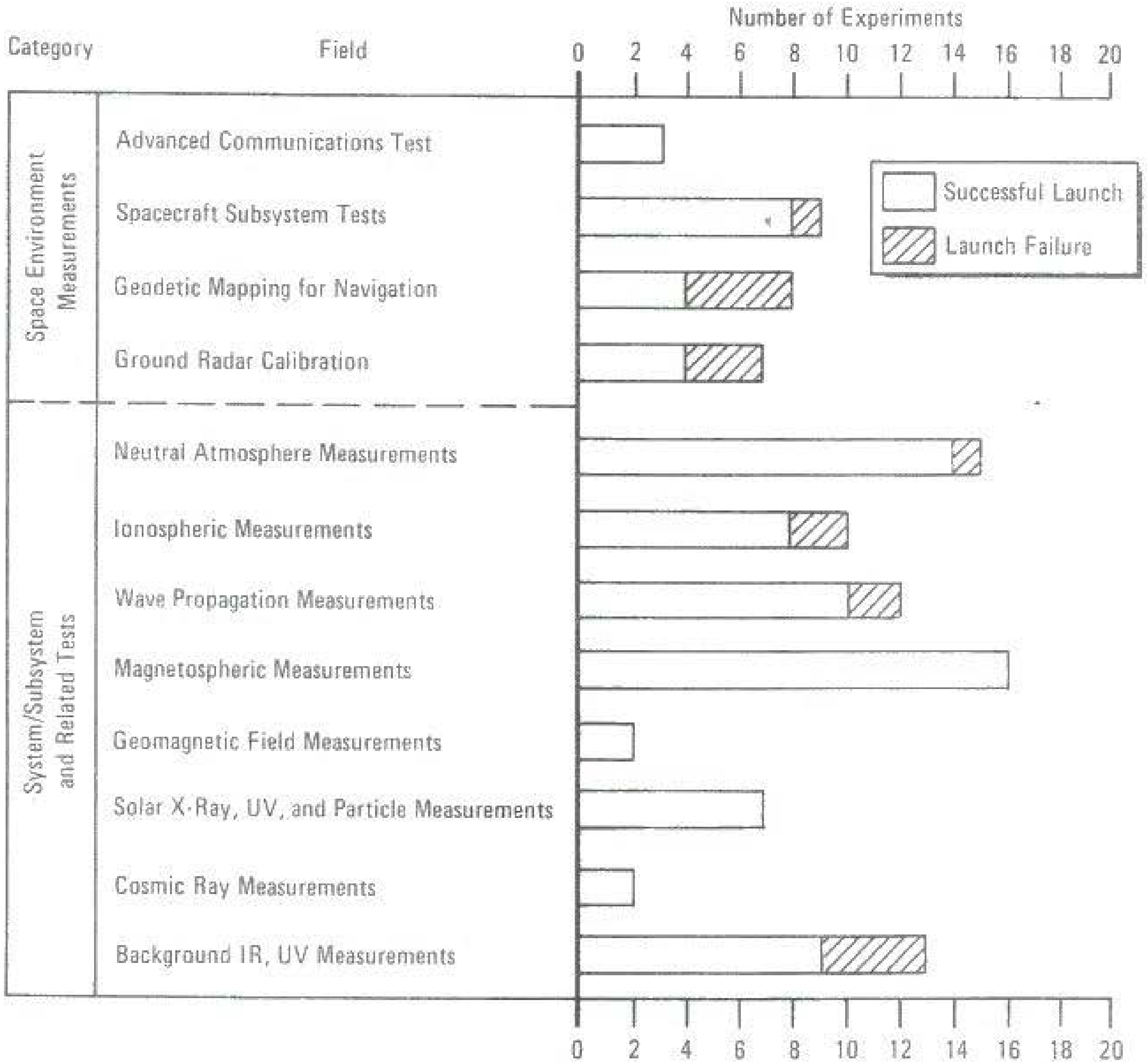
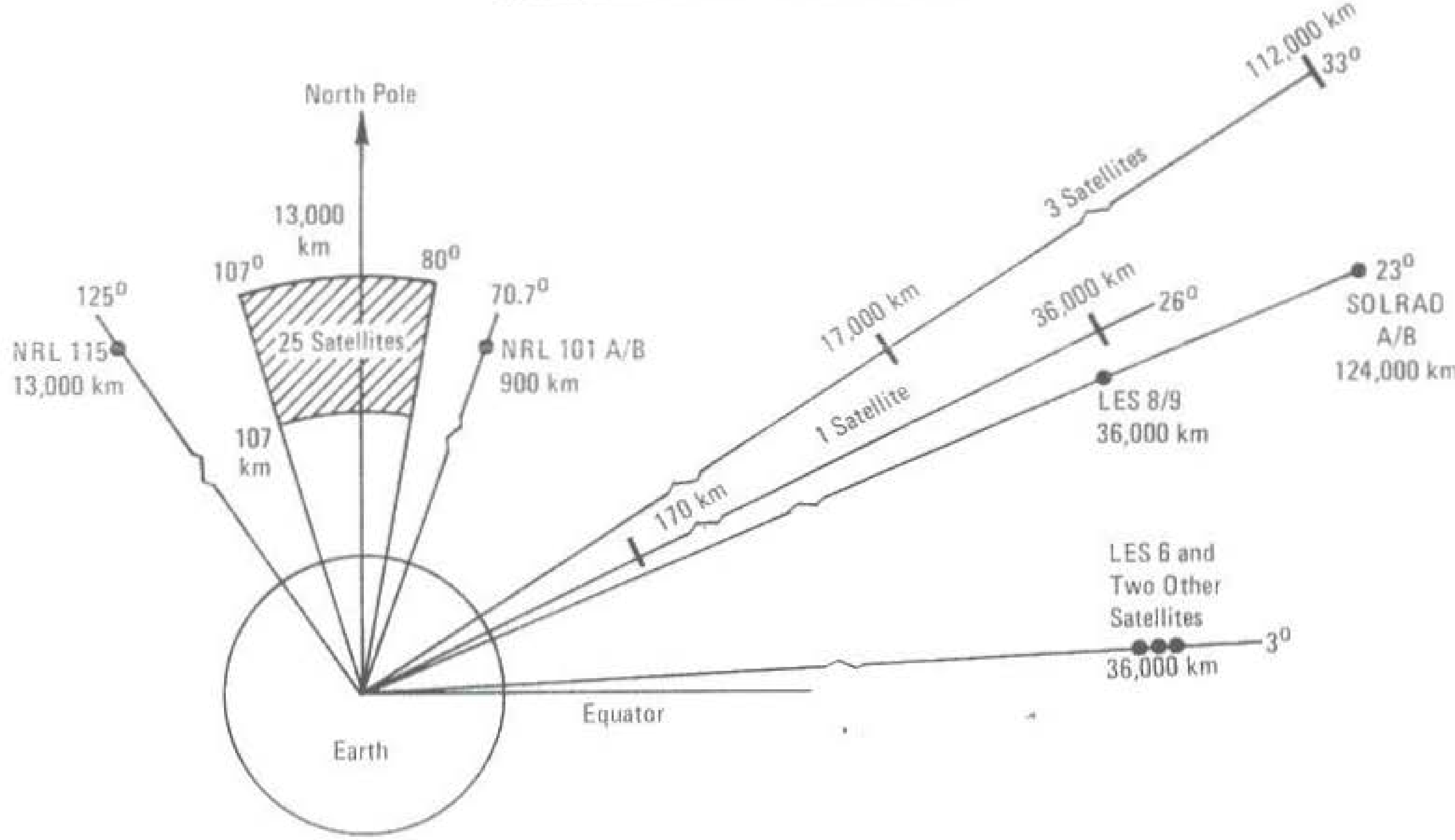


FIGURE 4
DISTRIBUTION OF EXPERIMENTS BY FIELD



N.B. The total number of experiments in this figure, 104, exceeds the 98 shown in other figures because six experiments belong to two fields each.

FIGURE 5
SATELLITE ORBIT DISTRIBUTION



Summary

25 Satellites in High Inclination Orbits   11 Satellites in Low Inclination Orbits   3 Satellites in Intermediate Inclination Orbits

11 in low-inclination orbits, and 3 in intermediate-inclination orbits.

By their very nature, the accomplishments of the individual system/subsystem and related test experiments are directly related to either military system development, systems validation, or system evaluation; therefore, their benefits to DOD are direct. The accomplishments of the individual space environment measurement experiments, on the other hand, are less directly related to the systems development efforts; therefore, their benefits to DOD are less evident. However, the contributions made collectively by the space environment measurement experiments in each field are beneficial to DOD in that they advance our knowledge of the space environment, which is critical to the reliability and survivability of space systems.

It is difficult to identify specific DOD systems development programs that made direct use of the space environment data generated by the STP experiments. Data from these experiments are generally stored in the NASA or DOD data centers—such as the Air Force station for the prediction of ionospheric effects on communications in Colorado Springs, Colorado—and their results are published in scientific journals, which are used widely by the military technologists.

We judged the military benefits of the environment measurement experiments by evaluating the technical success of each experiment and by examining how the field to which the experiment belongs relates to the military missions, and why it is important to make measurements in that field. We evaluated the experiment's technical success on the basis of our and the experimenter's judgment of the quality of the experimental results, and the scientific publications or documentation of the experimental results.

According to the experimenters' own evaluations of the performance of the experiments relative to their expectations, 46 percent of all experiments were better than 80 percent successful. At least 47 percent of the experimenters published their results in one or more articles in the open literature, and at least an additional 15 percent published descriptive documentations of their experiments or techniques. Data from many of the recent experiments are still being gathered and analyzed and therefore have not yet been published.

ACCOMPLISHMENTS OF THE SYSTEM/SUBSYSTEM AND RELATED TESTS

Nineteen experiments conducted tests in the following four major fields: advanced communications, space subsystem technology, geodetic mapping, and ground radar calibration.

Three communications experimental satellites—the Lincoln Experimental Satellites LES 6, LES 8, and LES 9—contributed significantly to the field of military communications. These experiments, designed and built by the MIT/Lincoln Laboratory and launched by the STP, have advanced space communications technology by a generation. LES 8 and LES 9 successfully [redacted] demonstrated communications among small and mobile ground terminals, fixed ground terminals, aircraft, and ships; they validated technologies to survive and continue dependable operation in a hostile environment by using radioisotope thermoelectric generators; their on-board signal processing demonstrated an antijamming technique; and they demonstrated the use of a highly stable, long-lasting, self-contained attitude-control gyroscope for future spacecraft. All of these accomplishments validated the technologies to make future military space

(b)(1)

communication systems more capable, reliable, and survivable.

Eight other experiments contributed to the advancement of space subsystem technology by testing: (1) a cryogenic system for advanced IR sensors for surveillance satellites; (2) a cadmium cell solar energy source for improved satellite survivability; (3) a communication system for jam-resistant and secure operation; (4) a flexible solar array system for space defense systems; (5) a passive thermal control coating to be used in Defense Satellite Communications System (DSCS); and (6) a yaw sensing system for possible use on reentry vehicles.

Four other experiments launched successfully by the STP contributed to geodetic mapping and navigation. The Sequential Collation of Range (SECOR) experiments improved the geodetic survey accuracy worldwide, which is significant for military target location and navigation. Another experiment proved a new concept in geodetic mapping, and yet another proved to be a forerunner to the Global Positioning System.

Four experiments were used to calibrate and check out the ballistic missile defense radars. Conical, cylindrical, and spherical objects of known cross sections were placed into orbits to simulate typical acquisition orbits, and the radars were calibrated by tracking these objects successfully. Thus, by helping to calibrate the ground radars, these experiments were highly beneficial to the Ballistic Missile Defense program and the Space Object Identification program.

CONTRIBUTIONS OF THE SPACE ENVIRONMENT MEASUREMENT EXPERIMENTS

Space environment here refers to the entire region around the earth above an altitude of approximately 10 kilometers. It consists of several regions with distinct characteristics, major regions being the upper atmosphere, the ionosphere, the magnetosphere containing trapped radiation, and the solar wind.

It is important to make upper atmospheric measurements to understand and predict the terrestrial weather, the dynamics of upper atmospheric nuclear explosions, the orbits and lifetimes of satellites, and the characteristics of the ionosphere.

The upper atmosphere is conventionally divided according to the temperature gradient into five layers: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. These layers absorb the ultraviolet radiation and X-rays from the sun and protect the earth from their harmful effects. This absorption, a major source of energy input into the atmosphere, depends upon the composition, density, and temperature of the atmosphere. It is therefore essential to measure the solar radiation and the atmospheric parameters to model the standard atmosphere, to understand its dynamics, and to make predictions.

Fourteen experiments orbited successfully by the STP measured upper atmospheric parameters using a variety of techniques. Some measured neutral composition and average densities of constituents, others measured localized density fluctuations and temporal density variations. Contributions made by these experiments may individually be modest, but collectively they are significant in furthering our knowledge of the upper atmosphere. The data from these experiments have been used to revise atmospheric models and to refine satellite drag and ephemeris calculations.

It is important to study the ionosphere because ionospheric disturbances cause worldwide communications interference and communications blackouts. The ionosphere, a weakly ionized region in the upper atmosphere, lies between about 50 and 1,000 kilometers altitude. It is conventionally divided into three so-called D, E, and F layers. Ionizations in these layers are produced by the Lyman-α, Lyman-β, Solar UV ($<3{,}000\text{Å}$), and X-rays. Long-range terrestrial communication is possible only because radio waves are refracted back to the earth by the conductive layers of the ionosphere. The wave refraction is dependent upon the ionospheric conductivity, which in turn depends upon the composition, density, and temperature of the ionosphere. These parameters change drastically with local time, season, solar activity, and after high-altitude nuclear detonations. Therefore, it is necessary to measure these parameters to understand the behavior of the ionosphere and to predict communications interference and blackouts.

Eight experiments orbited by the STP contributed significantly to the advancement of our knowledge of the ionosphere. These experiments measured the charged particle densities, composition, and temperatures. They correlated these measurements with the upper atmospheric electric and magnetic field measurements; investigated spacecraft charging, a significant threat to space system operations; and investigated the structure of irregularities in the ionosphere. Thus, collectively these experiments made valuable contributions to the understanding of the ionosphere, particularly to the understanding of the effects of nuclear weapons detonations on the ionosphere and communications.

The reliability of military communications depends greatly upon the propagation of electromagnetic waves in the ionosphere. Ten experiments studied the propagation of various electromagnetic radiations. Six studied ELF/VLF wave propagation, three studied HF wave propagation, one studied VHF through L-band wave propagation. These propagation experiments are vital to the development of the submarine communications technology. One of these experiments also measured the effect of antenna-loading by the ionospheric plasma, and another collected the statistics of radio signal scintillations at VHF through S-band produced by the irregularities in the ambient ionosphere. These statistics are important for predicting communications degradations produced by ambient or solar-disturbed ionosphere or by high-altitude nuclear explosions. Thus, these experiments have collectively obtained data that are essential for developing reliable military communications.

The Earth's magnetosphere contains stably trapped, quasi-trapped, and untrapped particles with high fluxes of electrons with a continuum of energies up to hundreds of MeV. It is essential to learn more about these particles not only to predict satellite lifetimes in the naturally hostile environment but also to predict the lifetime of the radiation produced by high-altitude nuclear detonations, which can damage spacecraft and cause prolonged blackouts in worldwide communications.

Eighteen experiments made measurements of the geomagnetic field and trapped radiation in the magnetosphere. Some measured trapped particle fluxes, others measured total radiation dosage received by satellites. The data from these experiments are helping to develop magnetospheric models, predict magnetic storm effects, and investigate the feasibility of satellite communication with VLF waves.

The solar wind emitted by the quiet sun contains low-energy electrons, protons, and few alpha particles. It is important to investigate the solar wind because it is responsible for many processes in the space environment. During increased solar activity, its particle components are responsible for the geomagnetic storms and the aurora, which cause radio blackouts and interference. The magnetic storms are usually accompanied by drastic changes in the radiation belts, the ionosphere, and the atmospheric drag experienced by the satellites.

Seven experiments made measurements of the solar wind during the quiet solar periods and during increased solar flare activity. The most noteworthy and wide-ranging contributions in this field have been made—and are still being made—by the two SOLRAD satellites. These highly successful satellites, designed by the Naval Research Laboratory, are currently providing excellent data on all major parameters of the solar wind. The goal in acquiring these data is to be able to forecast solar activity and understand sun-earth interactions. By providing the necessary data base, these experiments are helping to achieve this important goal.

Two experiments made measurements of the cosmic rays above the atmosphere. One measured high-energy particles and the other measured gamma rays. These measurements made a modest contribution to our knowledge of the cosmic ray background, which must be known to detect and assess atmospheric nuclear explosions.

The design and satisfactory operation of surveillance satellites require good knowledge of the background radiation in the infrared, visible, and ultraviolet wavelengths. A total of nine experiments gathered data on the Earth and celestial background radiation. Four of these measured the spectral variation of the infrared background and mapped celestial infrared background. Two experiments measured the nightglow below the experiment altitude and correlated it with the nightglow above the experiment altitude or with the precipitation of high-energy particles from the magnetosphere. The remaining three experiments mapped the sky in the Lyman-α wavelength and in the far and extreme ultraviolet wavelengths. All of these background measurements are essential for the design and operation of surveillance satellites.

CONCLUSIONS AND RECOMMENDATIONS

The 98 experiments supported by the STP have been highly beneficial to the DOD in that they helped advance military space technology and our knowledge of the space environment.

By providing timely support to a large number of highly diverse experiments at a moderate cost of $119 million over a period of 10 years, the Space Test Program has been a success. The program has provided invaluable support to the DOD research and development community, without which the community would have had no ready means of testing their systems or making space environment measurements.

The program has thus far provided flight opportunities for many experiments, large and small. We recommend that the program continue to do so.

On the basis of our experience gained in collecting the data for this study, we further recommend that for the DOD users to have easy access to the STP experimental results, the STP require the principal investigators of the experiments to submit abstracts with bibliographies of their results to the STP after flight and data analysis.

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Space Test Program
DOD R&D Satellite Experiments

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This note is an assessment of the benefits the Department of Defense accrued from the experiments supported by the Space Test Program. The Space Test Program has successfully orbited 82 experiments. These experiments were classified into two distinct categories: (1) system/subsystem and related tests and (2) space environment measurements. Results of the system/subsystem tests, directly useful to the DOD, are identified. The collective contributions made by the space environment measurements are also discussed. No attempt was made to evaluate the programmatic, procedural, or organizational matters of the program.