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Satellite Program

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The surge of interest in the earth satellite program had its basis in the assemblies of some 40 nations, meeting to plan and integrate the unprecedented study of man's physical environment known as the International Geophysical Year, 1957–58. This world-wide study primarily embraces those fields of geophysics in which observations must be conducted simultaneously over the earth if we are to achieve significant progress in our understanding of the earth and its atmosphere. Problems to be studied include aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity measurements, ionospheric physics, longitude and latitude determinations, meteorology, oceanography, seismology, and solar activity. Two additional areas of activity are of special interest: rocket studies of the upper atmosphere and the recently announced satellite studies, which represent a logical extension, technically and conceptually, of the rocket program.

How the satellite program came into being, the present status of plans, and the type of experiments under consideration are some of the questions of current interest. Since the announcement of the program on 29 July 1955, by the President, questions on these points have been asked often, by scientists and laymen alike. This article attempts to tell the story of the program.

The interest of the U.S. National Committee for the International Geophysical Year in earth-circling research satellites began with the adoption of resolutions, during the summer and early fall of 1954, regarding the desirability of such vehicles. These resolutions were adopted by three international scientific bodies: the International Scientific Radio Union, the International Union of Geodesy and Geophysics, and the Special Committee for IGY of the International Council of Scientific Unions (CSAGI). The resolution of most immediate interest is the one adopted on 4 October 1954 by the CSAGI:

"In view of the great importance of observations during extended periods of time of extra-terrestrial radiations and geophysical phenomena in the upper atmosphere, and in view of the advanced state of present rocket techniques, CSAGI recommends that thought be given to the launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with satellite experiments, such as power supply, telemetering, and orientation of the vehicle."

In view of these international recommendations, and in view of the advanced state of U.S. rocketry developments, the Executive Committee of the U.S. National Committee for the IGY (USNC-IGY) considered the possibility of constructing, launching, and observing an instrumented satellite. A special group was established for this purpose, composed of various members of the USNC Executive Committee and the USNC Technical Panel on Rocketry.

On the basis of recommendations made by the special study group, the Executive Committee decided that an instrumented satellite program not only was of scientific importance but was feasible, and it adopted a resolution which reads in part as follows.

"The Executive Committee of the USNC-IGY feels that a small artificial satellite for geophysical purposes is feasible during the International Geophysical Year if action is initiated promptly, and that the realization of such a satellite would give promise of yielding original results of geophysical interest."

The Executive Committee authorized the chairman of the U.S. National Committee to transmit the aforementioned findings and resolution to the president of the National Academy of Sciences and the director of the National Science Foundation. This was done on 14 March 1955.

Meanwhile the scientific and technical studies of the committee's special satellite group continued. By the early part of May, a preliminary program had been developed, and the committee directed its chairman to transmit the proposed program to the Federal Government through the National Science Foundation. This was done on 6 May 1955.

Late in July, the Government's approval of the satellite program permitted the chairman of the USNC to notify the CSAGI of our plans. In his letter of 26 July 1955, to Sydney Chapman, president of CSAGI and one of the world's most distinguished geophysicists, Kaplan said:

"The Committee on behalf of the National Academy of Sciences wishes to inform you at this time that, in response to the CSAGI resolution, the program of the United States for the International Geophysical Year now includes definite plans for the launching of small satellites during the International Geophysical Year.

"The United States National Committee believes that significant scientific data may be gathered as a result of this program in such fields as geodesy, atmospheric physics, ionospheric physics, auroral physics, and solar radiation. The participation of other nations engaged in the International Geophysical Year is invited, and to this end we shall provide full scientific information on the orbiting vehicle so that other nations may monitor the device and make appropriate observations. The United States National Committee looks for-

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ward to the interest and cooperation of other nations in what it hopes will be one of the great scientific achievements of our time."

On 29 July 1955, Chapman released this letter to the public at Brussels through CSAGI's secretary general, M. Nicolet. A few minutes later, the President's endorsement of the program was made public at the White House by James C. Hagerty, the President's press secretary:

"On behalf of the President, I am now announcing that the President has approved plans by this country for going ahead with the launching of small, unmanned, earth-circling satellites as part of the United States participation in the International Geophysical Year which takes place between July 1957 and December 1958. This program will, for the first time in history, enable scientists throughout the world to make sustained observations in the regions beyond the earth's atmosphere.

"The President expressed personal gratification that the American program will provide scientists of all nations this important and unique opportunity for the advancement of science."

Chapman replied to Kaplan on 3 August 1955. The substance of Chapman's letter is contained in the following three quoted paragraphs:

"On behalf of the CSAGI I wish to express great satisfaction that it was in consequence of the CSAGI resolution you quote, that your National Committee arranged for a study of the possibilities and value of the construction of a satellite vehicle for upper atmospheric and other scientific exploration.

"I am glad to know that this study was so successful that your Committee felt able to resolve to construct and launch small satellites as a part of the United States contribution to the International Geophysical Year, and to announce these plans publicly. The long experience of your scientists in rocket launching and construction, and the brilliant scientific use they have made of rockets for upper atmospheric and solar exploration, gives confidence that the plans so announced will be fulfilled.

"This will indeed be one of the great scientific achievements of our time, and will give occasion and opportunity for the cooperation of other nations in this outstanding part of the great enterprise, the International Geophysical Year."

These, then, were the early steps in the development of the academy's satellite program: the international resolutions recommending such an effort; months of preliminary study and planning by the U.S. National Committee for the IGY, culminating in the 10 March basic recommendation of the committee and 6 May program proposal to the Government; the exchange of letters between the chairman of the USNC-IGY (26 July 1955) and the president of CSAGI (3 August 1955); and the President's endorsement of the program on 29 July 1955, signaling the actual undertaking of the program.

The scientific basis for the satellite program is to be found in the need for basic, directly observed data, which ground-based experiments are unable to provide. The lack of such data is probably the single most important factor accounting for present incomplete explanations and theories regarding such fields as auroral and ionospheric physics.

Rocket soundings of the upper atmosphere have yielded significant results, and the IGY program includes a major rocket research effort. Some hundreds of rockets will be fired during the IGY, ranging from the relatively small balloon or aircraft-launched devices to high-performance Aerobees capable of reaching approximately 200 miles. The results of these experiments are expected to contribute to a better understanding of atmospheric events in two ways: First, rocket observations will provide direct data of various phenomena which can be used, so to speak, to calibrate ground-based observations. The latter, as with ionospheric soundings, provide rather conveniently and inexpensively extensive indirect data. Second, new discoveries may well be made, particularly of events screened by the earth's atmosphere.

Thus rockets permit us to make direct measurements of quantities that are either only indirectly observable or are not observable at all, from the ground. They also provide a technique for measuring the altitude dependence of various geophysical parameters. Unfortunately, rockets have two serious disadvantages: (i) their total flight is extremely short and the time spent in a particular altitude range is even shorter; and (ii) their flight paths are restricted in terms of geographic coverage.

Thus, in spite of the very great value of rocket data, much of which is attainable only by rocket methods, there exists a need for a device that can provide synoptic data over the earth, at high altitudes, over appreciable periods of time. As examples, one can cite the following: fluctuations in such solar effects as ultraviolet radiations and x-rays, cosmic-ray intensities, current rings encircling the earth, and particle streams impinging on the high atmosphere. These and other phenomena are among the most important problems connected with the physics of the upper atmosphere and with solar-terrestrial relationships.

Clearly an earth satellite would permit observations of the kind indicated in the foregoing paragraphs, and the value of these studies convinced the USNC of the merit of responding to the invitation of CSAGI. In its report last October to CSAGI, the committee indicated that the following types of experiments were under consideration: (i) determination of outer atmosphere densities by observation of the air-drag effect on the satellite's orbit; (ii) obtaining of more accurate measurements of the earth's equatorial radius and oblateness and of intercontinental distances and other geodetic data than are presently available; (iii) long-term observations of solar ultraviolet radiation; (iv) studies of intensities and fluctuations in intensity of the cosmic and other particle radiations impinging on the atmosphere; (v) determination of the density of hydrogen atoms and ions in interplanetary space; (vi) observations of the Störmer current ring; (vii) if possible, determination of the distribution of mass in the earth's crust along the orbital track.

How many and what experiments will be undertaken cannot be specified at this time. In part, these depend on the number, size, and pay-load capacity of the satellites. In part, they depend on choices yet to be made by the USNC, in collaboration with interested scientists, for in all probability more experiments will be proposed than can be fitted into the IGY satellite program.

Work on technical details of the satellite is currently under way. Information now available may be stated briefly: the satellites will be small; they will contain scientific instruments; they will be trackable from ground by optical and radio techniques; they will probably be visible to the naked eye under optimum conditions at dawn and dusk and certainly observable under good atmospheric conditions by means of binoculars and wide-field optical equipment.

In size the satellite may be described as about that of a basketball, although the shape has not yet been fixed. Each satellite will weigh more than 20 pounds but probably less than 50 pounds. The satellite will travel about the earth in an elliptical orbit, with a perigee distance of at least 200 miles and an apogee distance of some 800 miles. It is expected that the satellite will remain in its orbit for at least several weeks and perhaps for months: the greater perigee and apogee distances, the longer the life of the satellite as a result of reduced atmospheric resistance. The velocity of the satellite will be approximately 18,000 miles per hour, giving a period of about an hour and a half, depending on the precise perigee and apogee values.

The Government's endorsement of the academy's satellite proposal permitted the committee to proceed beyond the preliminary plans outlined in its 6 May document. Whereas the studies of the committee had been conducted on an ad

hoc basis, calling upon members of the USNC Executive Committee and the Technical Panel on Rocketry, as well as various consultants, it now became appropriate to establish a Technical Panel on the Earth Satellite Program. The membership of this panel is as follows: R. W. Porter, chairman (consultant, Communication and Control Equipment, Engineering Services Division, General Electric Company); Hugh Odishaw, secretary (executive secretary, U.S. National Committee-IGY, National Academy of Sciences); Joseph Kaplan (professor of physics, University of California at Los Angeles; chairman, U.S. National Committee-IGY, National Academy of Sciences); H. E. Newell, Jr. (acting superintendent, Atmosphere and Astrophysics Division, Naval Research Laboratory); W. H. Pickering (director, Jet Propulsion Laboratory, California Institute of Technology); A. F. Spilhaus (dean, Institute of Technology, University of Minnesota); Lyman Spitzer, Jr. (professor of astronomy, Princeton University); J. A. Van Allen (professor of physics and head of department of physics, State University of Iowa); F. L. Whipple (director, Smithsonian Astrophysical Observatory; professor of astronomy and chairman of the department of astronomy, Harvard University).

The functions of this panel are analogous to those of the other 12 technical panels of the USNC in the various IGY disciplines. The Technical Panel on the Earth Satellite Program, with such additional membership and consultants as are necessary, will have fundamental responsibilities, acting on behalf of the USNC, in further developing, coordinating, and directing the over-all scientific satellite effort. The panel expects to utilize contributions from many scientists and institutions, a feature that has characterized the planning of all IGY programs under the auspices of the USNC.

At the same time, the Government's support made it desirable to begin certain technical phases of the effort immediately if launchings were to be realized as early as possible during the 1957–58 IGY period. The committee had taken cognizance, in its 6 May proposal, of the need for logistic support from the Department of Defense: only through the use of this agency's facilities and rocket experience could the program be attempted economically and realistically. Accordingly, the committee called for this type of assistance.

In making this request, the committee had two major precedents: first, the Antarctic Program which requires extensive expeditionary and logistic support and, second, the rocket program. In both of these areas, the Department of Defense has responded and is making substantial contributions to the IGY program.

Following the President's approval on 29 July the committee's request for logistic support in the satellite program was granted. This support will be provided jointly by the three military services under Navy management. A group has already been established, directed by John P. Hagen of the Naval Research Laboratory, for the conduct of Project Vanguard, the name assigned to Defense's effort. Two contracts have already been issued for propulsion rocket vehicles, and Project Vanguard will conduct the operations necessary to get the satellite on orbit, following much the same pattern established for the IGY rocket program.

The satellite program, then, is already under way. Although it is clearly an exciting and significant endeavor, one should not lose sight of the difficulties of the enterprise. The committee's studies indicated that existing rocket technology provided a sound basis for the feasibility of the proposal. Yet the venture is truly a pioneering one, and partly for this reason the committee's 6 May document called for some ten instrumented satellites, with the hope that at least five or six would be successfully launched into their orbits.

The growing realization of the technologic feasibility of a satellite endeavor in recent years provided the impetus to international considerations of such a program. The German V-2 rocket developments of World War II, the high-atmosphere research rockets (for example, the Aerobee and the Viking) of the United States, and related rocket efforts of other nations created a body of literature and a technology that provided the foundations for a new departure. During the last decade or so the concept of small, research satellites for study of the high atmosphere has occurred to many thoughtful individuals. Members of the Upper Atmosphere Rocket Research Panel, an informal group of leading U.S. rocket and upper atmosphere scientists and engineers, have considered just such prospects. One of the most widely publicized recent proposals was that of S. F. Singer's MOUSE.

Such, then, was the climate at the Rome meeting in the autumn of 1954 when representatives of various nations met to coordinate the IGY programs, and out of it grew the CSAGI resolution advocating the satellite venture. This venture not only has grown out of the world-wide IGY Program but is a substantial and promising part of it. The intensity of effort to be devoted by more than 40 nations, investigating phenomena in some 12 geophysical disciplines, is augmented now by the results that the satellite program promises: observations of high atmospheric and interstellar events unhindered by the earth's lower masking atmosphere.

In this venture, other nations and other observers will share, for, as the President indicated, the satellite will be public. Its design and instrumentation will be made known. The frequencies of the telemetering system, which will radio back to earth the scientific observations, will be revealed. The results of observations will be published. These provisions, in keeping with the peaceful and cooperative spirit of IGY, will permit the satellite to be followed and observed throughout its course about the earth.

One year after the Rome meeting and some 2 months after the President's announcement, the nations of the world met again at Brussels, to integrate further their respective IGY efforts. The inspiring character of the President's announcement was clearly revealed. The scientists of the 40 or more other nations participating in the IGY received the news of the proposed U.S. satellite program enthusiastically. This reception was based in part on the great admiration by scientists of other countries for the past achievements of American rocket scientists. More important, however, this reception was based on the knowledge that the value of geophysical observations made during the IGY would be enhanced greatly by the addition of extensive, direct data obtainable only from research satellites.

Participation of scientists in this endeavor falls within the purview of the National Academy of Sciences, which established the U.S. National Committee for the IGY. This committee, with its subcommittees and panels, is charged with responsibilities for planning, directing, and executing the U.S.-IGY effort. The Government has cooperated extensively in the realization of the program, both program-wise and fiscally. The National Science Foundation, at the request of the academy, has assumed responsibility for the fiscal aspects of the program and has played a major role in the coordination of Government interests. Federal funds totaling $12 million have already been appropriated for the over-all IGY effort.