History of Rocketry and Astronautics

Proceedings of the Twentieth and Twenty-First History Symposia of the International Academy of Astronautics

Innsbruck, Austria, 1986

Brighton, United Kingdom, 1987

Lloyd H. Cornett, Jr., Volume Editor

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AAS History Series, Volume 15

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 9

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 1993

ISSN 0730-3564

ISBN 0-87703-376-5 (Hard Cover)
ISBN 0-87703-377-3 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198

Printed and Bound in the U.S.A.

Chapter 22

INTERNATIONAL GEOPHYSICAL YEAR TO INTERNATIONAL SPACE YEAR*

Herbert Friedman†

The International Geophysical Year (IGY) was the third milestone in a series of international cooperations in solar-system research. The First International Polar Year (1882-1883) involved a collaboration among eleven nations bordering on the Arctic region to study the influence of Arctic ice on weather. Fifty years later radio science had come of age, and plans were implemented to conduct a Second Polar Year (1932-1933) to study the ionosphere. When the Year began, 44 nations were committed to participate. Although science was feeling the budgetary austerity of the Great Depression, the practical application of radio knowledge derived from the Second Polar Year was worth many orders of magnitude more than the total investment in conducting the scientific program.

With the end of World War II, American, British, French, and Soviet teams undertook high altitude research with rockets. The idea of a grand campaign of ground-based, combined with space-based studies of the terrestrial environment motivated the organizers of the International Geophysical Year. Under the aegis of the International Council for Scientific Unions, a Special Committee for the IGY was established with Sydney Chapman as President and Lloyd Berkner as Vice-President.

The formal dates of the IGY were mid-1957 to the end of 1958. Over 40,000 scientists and technicians from 67 nations worked at 4000 observing stations covering the Earth from pole to pole. Hundreds of rockets were launched, but the crowning achievements were the Soviet Sputnik in 1957, and the U.S. *Explorer I* that discovered the Van Allen Belts in 1958.

The success of the IGY has prompted contemporary geoscientists to consider the possibility of a new generation IGY, to which they have given the name International Geosphere-Biosphere Program (IGBP). Special emphasis will be given to understanding atmospheric pollution and biogeochemical cycles, and the links between geophysical and biological processes in general.

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* Presented at the Twenty-First History Symposium of the International Academy of Astronautics, Brighton, United Kingdom, 1987.

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Momentum is now gathering to restore a broad-gauged international cooperation in space research and exploration in the historical context of Columbus' landing in America 500 years ago. 1992 has been designated an International Space Year (ISY). The ISY will be a celebration of the initiation of a golden age of space science, exploration, and applications. European and Japanese space programs will be flourishing, and the U.S. should have moved from post-*Challenger* depression to courageous new initiatives. The Soviets, spurred by their new policy of Glasnost, could become welcome partners to Western science.

1983 was the centennial of the First International Polar Year (1882-1883); the 50th anniversary of the Second Polar Year (1932-1933); and, the 25th anniversary of the International Geophysical Year (IGY, 1957-1958). Karl Weyprecht, an Austrian Lieutenant, made the case for the First Polar Year in an eloquent appeal to the Austrian Academy of Sciences on January 18, 1875.

> Purely geographical research and Arctic topography, which until now have stood in the foreground of all polar expeditions, must, with respect to the great scientific questions, recede into the background. The answers, though, will occur only when those nations pretending to aspire to the heights of contemporary, cultural endeavor decide, without regard to national rivalry, upon common measures. In order to secure decisive scientific results, we require a series of simultaneous expeditions whose aims must be, through dispersal over several points of the Arctic region and using identical instruments in line with identical instructions, to conduct a simultaneous, year-long series of observations. Only thereby shall we acquire the material for solutions to the great problems of nature that reside in the Arctic ice, and only then shall we earn the reward for those considerable resources that have hitherto been squandered in labor, endeavor, deprivation and money in the polar region.

The First Polar Year involved those countries in North America and Europe on the border of the Arctic circle that had a common concern for the influence of Arctic ice on their weather patterns. Eleven nations joined their efforts to study the aurora and magnetic storms as well as meteorology.

Fifty years after Weyprecht's initiative, radio propagation via the ionosphere was a subject of great scientific and practical interest. A Second Polar Year was accordingly planned with a focus on ionospheric studies. Its charter emphasized the study of:

> the one or more electrically conducting layers at great heights, which are believed to be connected with radiation from the Sun and the phenomenon of the aurora. The aurora in turn is in some way associated with the development of magnetic storms, which form a fundamental problem in terrestrial magnetism.

Unfortunately, the Second Polar Year coincided with the height of the Great Depression. The plans to exploit the use of Robert H. Goddard's new rockets to carry instruments into the high atmosphere never materialized. Still, 44 nations participated in a more modest program, and the practical applications of scientific radio knowledge gained from their efforts was worth many orders of magnitude more than the investment in the research program.

With the end of WWII, geophysicists were keenly aware of the new potential of rockets for carrying scientific instruments to high altitudes, where the upper atmosphere could be studied directly. The captured German V-2 rockets in particular offered an immediate resource, and the scientific community grasped the opportunity to substitute their sensing devices for the weight of the explosive previously carried in the warhead. Until then, direct probes of the upper atmosphere had been limited to balloons that barely reached the level of the ozone maximum. The concept of a grandly organized international campaign of high altitude research, supported by all the classical techniques for remote sensing from the ground, was very appealing.

At an informal dinner party in the home of James A. Van Allen on April 4, 1950, the guests included Lloyd Berkner and Sidney Chapman. Out of their discussion came agreement to proceed with a formal proposal for an International Geophysical Year. Chapman soon became President of the Special Committee for the IGY under the International Council of Scientific Unions, and Berkner its Vice President. There followed years of intensive planning of the details of what eventually matured into the most successful demonstration of international scientific cooperation ever achieved. For the first time, the curtain was drawn aside that had hidden the research of Soviet scientists from the western world, and many scientists from underdeveloped countries found opportunities to associate and collaborate in the sophisticated science of the great powers.

The Special Committee met in Rome in 1954, and discussed the focus of IGY programs. Two major areas were singled out for special attention: Antarctica and outer space. Chapman soon expanded the scope to truly global programs in all aspects of the terrestrial and atmospheric sciences.

From mid-1957 to the end of 1958, some 40,000 scientists and their assistants from 67 nations established thousands of observing stations covering the Earth from pole to pole. The most spectacular achievements were the orbiting of the Soviet Sputnik in 1957, followed by the U.S. *Explorer I* in 1958, and the discovery of the Van Allen radiation belts. The Antarctic program involved 12 nations. Forty-eight new stations were established on the margins and in the interior of the continent. By the time the IGY was completed in 1958, the value of international cooperation in global research programs was firmly established.

In the United States, the IGY was planned as a large number of individual and small team efforts that were rather inexpensive, except for the rockets from which to conduct high altitude research, and the development of the Vanguard satellite program. The initial estimates were fairly modest, and funds were to be obtained from Congress via the National Academy of Sciences. An administrative mechanism was set up, whereby the military sponsored laboratories and their university contractors could supplement their normal programs with IGY funds.

It prompts a sobering reflection on the fragility of support for pure scientific research, even when backed by Presidential proclamation, when history recalls how close we came in the U.S. to abandoning all the planned rocket experiments of the IGY. Three organizations that were the principal performers of the U.S. rocket programs projected a total estimated cost of $1.3 million. Van Allen, at the University of Iowa, sought support for 25 Rockoons at $1,800 apiece. NRL had decided to fire 25 Aerobees at White Sands and the newly constructed facility at Fort Churchill, Canada. The Air Force planned on launching 15 Aerobees, divided between White Sands and Canada, and some 25 balloon-borne and aircraft-launched rockets. In September 1957, it appeared that the Air Force, under pressure from the Office of the Secretary of Defense, would abandon its support for two research groups at the University of Michigan and 17 or 18 planned rocket launches.

The U.S. National Committee for the IGY warned that:

> the budgetary situation in the DoD looks quite bleak and shows little chance for improvement. The representatives of all DoD agencies participating in the program are deeply concerned that the next few months will reveal widespread shortages in the internal funds required to complete the scientific aspects of the IGY rocket programs . . . the situation at the University of Michigan appears desperate. Suddenly it appeared that due to national policy money had become more than tight . . . almost non-existent. The funding shortfall would force the cancellation of the Fort Churchill activities, all the Navy rockets, all the Michigan rockets and all of the Iowa and Ballistic Research Laboratory rockets.

Homer Newell, Chairman of the IGY Committee, commented, "Needless to say, our IGY scientific program will be essentially wrecked and the United States will have reneged on a major international commitment." The Rocket Panel of the Academy viewed the crisis even more severely:

> It is extremely unfortunate that we in this country find ourselves in such a position in regard to our rocketry at just the time when Russia has impressed on the world the scope, magnitude and success of her effort in this field. We hope that short-sighted national policy will not lead this country to surrender leadership in an important field, namely, upper atmosphere rocket research, in which a few weeks ago we were clearly ahead.

Sputnik saved the day for the United States' IGY scientists! Emergency funding was quickly forthcoming after the Russian satellite started to orbit overhead, and 226 rockets were fired as part of the official IGY programs. The outstanding scientific accomplishments of the IGY were: the discovery of the Van Allen Radiations Belts with the U.S. *Explorer I* satellite; and, the studies of solar flares that led to the proof of X-rays as the source of radio fade-out.

An example of the kind of IGY activity carried out with modest resources and a high degree of cooperative organization was the auroral research effort. Auroral morphology was documented by an extensive network of all-sky cameras that covered the auroral scene from horizon to horizon. All told there were 114 cameras in operation in the Arctic and Antarctic. Hundreds of thousands of photographs were taken at one-minute intervals all through the night to reveal the large scale morpholog of the aurora. These observations involved more amateurs than any other IGY endeavor. About 430 sky watchers fed 18,000 hourly reports on standardized forms into an auroral data center at Cornell University. Yet the fruit of all this diligent effort pales in comparison to the scientific yield from one recent imaging scientific satellite, Dynamic *Explorer I.* Twenty-five years after IGY, its scientific programs look primitive in comparison to the power of present space science and modern computer capabilities to manage data.

In subsequent years, the IGY tradition was carried over into many follow-on programs, but somehow the persuasion of international cooperation seemed to be dwindling. On several occasions in 1983, the 25th anniversary of the IGY, national and international meetings were used to dwell with nostalgia on the wonderful past experience of IGY, but some scientists thought the time might be ripe again to undertake a modern version of the IGY with all the wonderful new power of remote sensing from space. It seemed that the time was opportune to integrate the approaches of the physical scientists and the life scientists in a collaboration that has come to be called the International Geosphere-Biosphere Program (IGBP)

The ground work for the organization of the IGBP was laid at the symposium sponsored by ICSU at the 1984 General Assembly in Ottawa. ICSU appointed an *ad hoc* committee to develop a plan for implementation of an international program, and formally adopted its proposal two years later. The report described an IGBP in outline as follows:

> The IGBP will be a carefully designed program of research directed at providing the information we need to assess the future of the Earth in the next 100 years, with an emphasis on processes that change on time scales of decades to centuries. It will be a program of basic research, with almost immediate practical applications in the management of resources at national and international levels, and a means of improving the reliability of warnings of global change of significance to our environment and to humankind.

Topics suggested for early emphasis in the IGBP include: (1) studies of biogeochemical cycles; (2) studies of the ocean euphotic zone; (3) studies of soil dynamics and soil chemistry; and, (4) studies of variable solar inputs to the Earth.

On May 15, 1986, President Reagan asked the Congress of the United States to endorse the concept of an International Space Year (ISY). His message read:

> A major objective of an ISY should be to maximize, through international cooperation, the achievements and benefits of the current and prospective space programs of the participating world community. Such efforts should emphasize the involvement of both the developed countries and the developing countries in ways that demonstrate the benefits to everyone from discoveries in space science and the practical utilization of space.

President Reagan's message to the Congress is reminiscent of President Eisenhower's endorsement of the IGY, more than a quarter century earlier.

Since the earliest proposal for an International Space Year by Senator Matsunaga, there has been a rapidly growing agreement internationally that an ISY in 1992 would be a highly appropriate way to commemorate the 500th anniversary of Columbus' landing in the New World. The activities to be carried out under the aegis of an ISY should emphasize:

> **Discovery** - with a focus on science such as conducted during the highly successful International Geophysical Year (IGY), 1957-1958.
>
> **Exploration** - expressing the human imperative to seek new worlds in the sense of Columbus and other explorers. For the time frame of the ISY, exploration must, of course, be limited to the solar system.
>
> **Utilization of Space for Humanity** - Studying the geosphere-biosphere by means of remote sensing in an effort to protect the environment and to mitigate the hazards of natural and man-induced disasters.
>
> **Education** - that seeks not only to contribute to human understanding of the universe but to inform the public about the benefits of space activities.

ISY is in its earliest stages of formulation, but confusion has arisen in many quarters about the relationship of ISY to IGBP. IGBP is a long term interdisciplinary cooperative research program aimed at advancing scientific knowledge that will improve the predictive capabilities regarding global change on planet Earth. Now an approved ICSU program, it will proceed for at least a decade, whether there is any ISY or not. ISY is a celebration of the spirit of discovery and exploration of unknown frontiers, and it will have both a strong public education component and a promotion of international cooperation in space in the mode of the IGY. It could provide an important framework for, and be supportive of, the IGBP in terms of governmental and public backing. In addition, the ISY could serve as one means of formally launching the operational phase of the IGBP.

In terms of scope, the IGBP is much more sharply focused than the ISY. It will examine: the interactive physical, chemical, and biological processes that regulate the total biosphere; the unique environment that it provides for life; the changes that are occurring in the system; and, the manner in which they are influenced by human actions. While it will take advantage of and establish formal connections with contemporary programs, it will be essentially a totally new effort. The ISY is an extremely broad concept involving science, applications, and space technology. It will place strong emphasis on exploration and education. Whereas the IGBP is an inward looking program, ISY will look outward as well, with emphasis on space plasmas in the terrestrial environment, astronomy, and exploration of the solar system.

ISY will take advantage of the large menu of international space projects already in preparation for launch and operation in the 1992 time frame to optimize coordination for maximum scientific yield. While it is a comparatively straightforward task to plan cooperation in space missions, and much is certainly already being done, ISY will make a special effort to complement the major space missions with supporting ground-based balloon and rocket campaigns that can be conducted at cost levels within the capabilities of the lesser developed countries. When it is recognized that three quarters of the world population lives in lesser-developed countries that have only six percent of the world's scientists, the importance of bringing those few scientists into partnership with the sophisticated scientific programs of the richer countries cannot be overemphasized. Most of the remote sensing programs of the IGBP will require complementary ground-truth measurements in every part of the world.

Many international space programs now in planning for the ISY time frame offer scope for coordination and enhancement with a host of ground-based supporting measurements. In particular, the International Solar-Terrestrial Physics Program (ISTP) can provide an ideal format for international cooperation. At the present time, instruments are being developed in the U.S., Europe, Japan and the U.S.S.R. for a collection of satellites that will be launched in the 1992 time frame. These include GEOTAIL (ISAS), the Solar and Heliospheric Observatory (SOHO/ESA), CLUSTER (ESA), and NASA's Global Geospace Science (GGS) missions. The goal of these missions is to arrive at a global understanding of the production and flow of energy within the Sun, its release to the heliosphere, and its impact on the magnetosphere and the ionosphere. In the U.S., about 200 scientists from 20 universities have been selected to participate. A data-networking system is in preparation to make the entire scientific data base that will be collected available to the worldwide scientific community in a matter of weeks. Preparations in Japan, ESA, and the U.S.S.R. are on a similar scale.

Highly complementary to the ISTP is CRRES, the Combined Release and Radiation Effects Satellite, that will release chemicals in a low equatorial Earth orbit to be observed from the ground with telescopes, radars, and cameras. As the chemicals spread out in colored tracers and generate ionic reactions, they reveal the wind patterns for hundreds of miles. Ground observing facilities will follow the tracers in the Caribbean area and the northern part of South America, including the Arecibo and Jicamarca Observatories in Puerto Rico and Peru, supplemented by tracking aircraft. CRRES will subsequently be transferred to a geostationary orbit, where massive releases will be made in the vicinity of the plasmapause.

Another example of how comparatively simple and inexpensive rocket campaigns can be, combined with complex spacecraft missions such as the ISTP, was the 1987 Greenland II campaign, in which nine rockets were launched from an area that has no permanent launching facility, but is especially interesting because it lies under the polar cusp. Ten institutions from Canada, Denmark, and the U.S. coordinated their measurements for three months during mid-winter.

Numerous examples of the potential of any ISY come readily to mind, but it is urgent that formal organizations be set up and serious definitions of activities be discussed and programs implemented. Within the ICSU family of scientific unions and special committees, COSPAR would seem to be the most logical choice for management of the scientific components of an ISY. At its general assembly in Toulouse, France, COSPAR drafted a statement to ICSU outlining the concept of an ISY, and volunteered to be the ICSU base for development of ISY activities. ICSU will consider its options in the Fall of 1987. The International Astronautical Federation can do much in the ISY context to foster technological symposia on the engineering aspects of space station plans, new transportation systems, robotics, and man-machine interfaces in microgravity and artificial gravity environments. The resources of COSPAR and the IAF should be mobilized for educational activities.

While all of the above discussion is in the context of an International Space *Year*, it is implicitly recognized that the program must run for three or four years to have substantive accomplishments.