https://ntrs.nasa.gov/search.jsp?R=19690013030 2020-07-16T10:47:26+00:00Z

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

CENTER FOR SPACE RESEARCH

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FACILITY FORM 602

(ACCESSION NUMBER)	(THRU)
32	1
(PAGES)	(CODE)
[illegible]	30
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

NGL-22-009-019

THE WORLD-WIDE SPREAD OF SPACE TECHNOLOGY

by

E. B. Skolnikoff
and
J. H. Hoagland

CSR TR-69-5 October 1968

ACKNOWLEDGEMENT

This paper, supported in part by the M.I.T. Center for Space Research, has also been published as a chapter in the American Assembly book Outer Space, Prospects for Man and Society, (revised edition) edited by Lincoln P. Bloomfield and published by Frederick A. Praeger, New York, 1968.

The World-wide Spread of Space Technology

Eugene B. Skolnikoff
Department of Political Science
Massachusetts Institute of Technology
John H. Hoagland
Browne & Shaw Research Corporation

The rapid advances in space technology during the first decade of the space age have depended heavily on the intense rivalry in political and military affairs of two very wealthy nations. Without that rivalry, it is doubtful if either the Soviet Union or the United States would have begun or maintained the remarkable pace of development in capabilities to launch heavier and more complex payloads into space that has characterized the first decade of space activities.

The rapid developments, and the political attention devoted to the space race, have also served to increase interest in national space activities in countries other than the United States and the Soviet Union, particularly other major industrial nations. However, these industrial nations, lacking sufficient resources, have found that the space age has presented them with new and vexing issues involving not only the establishment of sensible space objectives, but also the question of their fundamental ability to stay abreast of the two superpowers in modern technology. They have in their grasp some, but not all, of the technical, industrial, and financial resources needed to undertake space programs comparable to those of the superpowers. And they lack the sense of purpose necessary to the creation of a political consensus that would favor intensive and proportionally

enormous space efforts. Many of the second-rank industrial nations therefore face perplexing decisions regarding both the advisability, and the means, of remaining in the front ranks of technology. For these nations, the first decade of the space age--with its widening disparity in technological prowess between themselves and the superpowers--has precipitated a crisis of identity, one manifestation of which has been the heated controversy over the "technology gap" between the United States and nations of Western Europe and, to a lesser extent, Japan.

To the nonindustrial countries of the developing world, the space achievements of the United States and Soviet Union may be, in the long run, even more significant and disturbing. If these achievements add to the sense of separation, discrimination, and frustration felt in much of the developing world, or if they serve to advance the military capabilities of the developing countries rather than their economic growth, it seems very likely that the present technological controversy among the industrial nations will be laid to rest long before a solution is found to the problem of narrowing the gap with the less developed world.

More generally, the spread and continued advance of space technology will raise urgent issues related to questions of international control, regulation, and settlement of disputes. These are subjects that are likely to cause political problems but also offer opportunities to develop international machinery and international law that can serve to enhance peace and security.

Thus, the rate at which space technology spreads throughout the world, the uses to which it is put, the developments in other fields that it may

pre-empt, and the international political machinery growing up around space technology, are subjects of vital importance to future international relations.

In this chapter, the spread of space technology is considered first as it relates to the major industrial countries, and second in relation to the nonindustrial world. It is also important to distinguish at the outset between two kinds of spread. The first is the spread of more or less independent capabilities by nations or groups of nations to mount space activities. The second is a sort of induced spread, fostered by the spacefaring nations to promote cooperative programs which are primarily dependent on the technology of the donor, or to apply the donor's space technology directly or indirectly to the requirements of another nation.

Space Programs in the Industrial Countries

Apart from the United States and Soviet Union, the independent capability to engage in space activities resides mainly in five countries. In Western Europe, Britain, France, and Germany have important capabilities. In Asia, Japan and, to an unknown degree, Communist China, have similar qualifications. In order to consider the capabilities of these nations in their proper perspective, it is important to remember that their expenditures on space activity have been only a small fraction of the amount being spent by the United States and, presumably, the Soviet Union.* Especially with

*In 1966, France had a scheduled expenditure of $73 million on space, Germany $60 million, Britain $47 million, and Japan $12.5 million, in comparison with approximately $6,000 million in the United States.

regard to Western Europe, it is not difficult to be misled by a confusing array of proposals and design studies to the conclusion that rapid progress in space technology is being made. In fact, however, the multiplicity of space programs proposed for the late 1960's and 1970's really indicates a need for a more unified sense of direction in European space activities. As one eminent British scientist has observed:

> Thus Western Europe enters the second decade of space flight still with no clear idea of her eventual destination in space or even of the initial route that must be followed. The simple purpose of the U.S. and U.S.S.R. to explore the Moon and planets both with manned and unmanned spacecraft (which is the most powerful reason for a space program) is missing. It is too expensive for Europe to contemplate, at least in the next 10 years, and important subsidiary objectives must therefore be found.*

But the identification of subsidiary or any other objectives, and their systematic pursuit, require agreement and common enterprise, preferably under the direction of a single authority. Western Europe has consistently been tantalized by the possibilities available to it if its technical and economic resources could be aggregated. As the following table illustrates, the combined resources would be very impressive, enabling Europe to undertake space programs which could be competitive with the two superpowers. (The table also indicates, however, that in the mid-1960's, in proportion to GNP Western Europe was making about one-twentieth the allocation to space being made by the United States, and about one-fortieth that of the Soviet Union.) This awareness of potential strength has led to the initiation of several joint ventures, such as the European Launcher Development Organization

---

*L. R. Shepherd, "The First Decade of Space Flight on the European Scene," Aeronautics & Astronautics, October, 1967, pp. 62-68.

	United States (1965-66)	Western Europe*	USSR (1964-65)
Gross National Product (GNP) (millions of dollars)	639,000	429,000	287,000
Population (millions)	192	289	225
GNP per capita (dollars)	3,330	1,485	1,275
Part of GNP devoted to research and development (per cent)	3.1	1.4	2.8 (1962)
Space budget (millions of dollars)	6,650	210	6,000(est.)
Part of GNP devoted to space (per cent)	1.05	0.05	2(est.)

*Includes Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

SOURCE: Centre Nationale d'Études Spatiales, La Recherche Spatiale, Vol. VI, No. 6(June-July, 1967), p. 16.

(ELDO), the European Space Research Organization (ESRO), and the industrial consortium EUROSPACE. Unfortunately, these combined efforts have consistently been impeded by the hard political realities of conflicting national interests and objectives, as well as rivalries within the combined structure. These impediments have been reflected in delays, excessive costs, and the constant threat of cancellations. Therefore, independent national space programs, necessarily smaller in scale, have never been completely abandoned in Western Europe and may yet become a more important element in European space planning.

The figures provided in the table fortify the commonly accepted estimate that, even in the unlikely event that some of the other industrial powers

as Britain, France, West Germany, and Japan were to increase their space expenditures drastically--for example, to about one-half of 1 per cent of GNP per year--the United States and the Soviet Union would still remain the predominant space powers by any standard of measurement. But this kind of assertion, although factual, may also be somewhat misleading. It is important to keep in mind that the two superpowers have made an extremely large investment in both unmanned and manned space exploration, but have concentrated resources in support of a manned lunar landing. (In fiscal 1966, for example, the Apollo program alone accounted for about 60 per cent of NASA's total $5.2 billion budget.) If the cost of a manned lunar program or other highly ambitious programs of manned space exploration were omitted, then smaller budgets of other countries would appear more competitive, especially in the practical application of artificial earth satellites.

It is worth while to review briefly some of the trends in booster development by the various industrial nations or international consortia. These summaries are not meant to be complete, but merely to illustrate the kinds of programs that have been undertaken or considered.

ELDO

In addition to Britain, France, and Germany, four other nations are also members of ELDO: Italy, Belgium, the Netherlands, and Australia. The ELDO concept was proposed by Britain in 1960. Although a "Convention Establishing a European Organization for the Development and Construction of Space Vehicle Launchers" was signed by the seven nations on March 29, 1962,

the convention did not actually become effective until 1964, and costly delays were therefore encountered from the beginning. The convention states that:

(1) The Organization will have as its aim the development and construction of space-vehicle launchers and their equipment suitable for practical applications and for supply to eventual users.
(2) The Organization shall concern itself only with peaceful applications of such launchers and equipment.

The convention also provides that "each Member State which has contributed to the cost of a program of the Organization shall have the right to procure, for any peaceful purpose of its own, the launchers and equipment jointly developed under such program or any part thereof." (The term "peaceful" in these statements is understood to mean "nonmilitary.")

ELDO has been developing the following launchers:

ELDO-A, or Europa I. This is a three-stage vehicle of which the first stage is British (Blue Streak), the second stage is French (Coralie), and the third stage is German. The vehicle was designed to launch 2,300 pounds into a near-earth circular orbit.

ELDO-PAS (Perigee-Apogee System). This is an ELDO-A, supplemented by perigee and apogee motors and inertial guidance, intended to be capable of placing communications satellites weighing 300 pounds or more in geostationary orbits at an altitude of about 23,000 miles. The ELDO-PAS is scheduled to be operational in about 1970.

In addition, there have been several studies of improved ELDO launchers that could be operational in the 1970's, but it is far from certain, for reasons discussed later, that they will actually come into being. The main studies are concerned with the ELDO-B-1, with an improved second stage which

would be capable of placing a 4,000-pound payload into a 220-nautical-mile polar orbit and, with the addition of a satellite apogee motor, of placing up to 1,100 pounds in a geostationary orbit. The second important possible launcher would be ELDO-B-2, with upgraded second and third stages, capable of placing 6,700 pounds into a 220-nautical-mile polar orbit or up to 4,400 pounds in a geostationary orbit. Developments of this magnitude, however, would depend on common agreement within Europe and on a single relatively powerful space authority, strongly backed by all the participating governments. There is little reason to believe that any of these preconditions are likely to exist until well into the 1970's at least.

France

Since 1958, France has been developing and producing long-range missiles as part of its strategic force de dissuasion. Taking advantage of this military effort, France also initiated a space program and in 1965 became the third nation to place a satellite in orbit. A question of special importance to France in laying the groundwork for national or European space ventures of the future is the availability of larger boost vehicles. Out of the French intermediate-range ballistic missile (IRBM) program came the present French boost vehicle, the Diamant, which has launched all but one of France's early satellites.* (One French satellite,

*SEREB (Société pour l'Étude et Realisation d'Engins Balistiques), which directs the French IRBM effort, devised a plan in 1960 for developing a satellite booster based on research rockets used in the IRBM program. Three of these research vehicles, Émeraude, Topaze, and Agate were used as the stages of the Diamant booster. In November, 1965, France became the third nation to orbit a satellite by means of an indigenously developed launch vehicle.

the FR-1, was launched by a U.S. Scout rocket.) The Diamant is a three-stage vehicle based on research rockets which were developed for the intermediate-range missile program. It is roughly comparable in performance to the U.S. Scout rocket. Therefore, although it is useful as a relatively inexpensive vehicle for launching small spacecraft, it is not large enough to support an ambitious national space effort.

The ELDO consortium has therefore been especially important to France because it provides access to large boosters at an acceptable cost at a time when France is heavily obligated in its military effort. Thus France has supported continuation of the ELDO project, and has placed options to purchase two ELDO vehicles for the launching--in about 1970--of the proposed joint Franco-German Symphonie communications satellite, a field in which France has a particularly strong interest.

At the same time, the French Government also authorized the development of an improved national booster, the Diamant B which, although considerably smaller than the ELDO boosters, is also less expensive and can be used as a work-horse vehicle for the national space effort.* The Diamant B, scheduled to make its first flight from the French Guiana range in 1969 or 1970, will be capable of placing 200- to 300-pound payloads in relatively low orbits.

French space planners have generated a variety of proposals for independent or strictly European satellite communications networks,but it is difficult to

---

*The Diamant B will generate 79,000 pounds of first-stage shrust, compared with Eldo's first-stage thrust of more than 300,000 pounds.

predict which of them may come into being. There are special French interests in satellite links between France and its former African colonies, as well as the Middle East and Latin America, but many uncertainties still surround these proposals. In addition, France has also shown a strong interest in the military uses of space--especially in navigation, geodesy, meteorology, and other types of satellites to enhance the effectiveness of its strategic missile force.

In addition to its membership in joint European space organizations such as ELDO, ESRO, EUROSPACE, and the Conference on Satellite Communications (CETS), France has engaged in a number of civilian space exchanges and joint operations with the United States, including two satellite projects, several sounding-rocket programs, ground-based cooperative experiments, and personnel exchanges. With the Soviet Union, France holds an agreement for cooperation in color-television broadcasting involving the employment of the French SECAM television system in conjunction with the Soviet Molniya satellite. In addition, France and the U.S.S.R. cooperate in the launching of sounding rockets from the Indian launch site at Thumba. There have also been discussions about the use of Soviet boosters to enable France to launch larger satellites, such as the 660-pound Roseau.

The French civilian space budget for 1966 stood at $72.9 million, less than one-tenth of 1 per cent of GNP. Of this amount, roughly two-thirds was allocated to the national space program and the remainder to the joint European programs ELDO and ESRO, in marked contrast with Britain, which has allocated about two-thirds of its space effort to international programs. The French space budget was expected to increase considerably during the late 1960's.

United Kingdom

Britain has been the largest single contributor to ELDO, both financially and technically. It has provided about 38 per cent of ELDO funding, and the availability of the already developed Blue Streak as the first-stage booster for the ELDO vehicle has undoubtedly been the largest single technical contribution to the project.

The technical element which still sets the British space program apart from the other European countries is the Blue Streak booster, which generates about 300,000 pounds of thrust. In the mid-1950's Britain developed, with U.S. technical assistance, the Blue Streak intermediate-range ballistic missile. The thrust unit was built by Rolls-Royce under license from Rocketdyne in the United States, and Hawker Siddeley built the air-frame under license from General Dynamics. By the time that the project was canceled in 1960 approximately 500 static firings had been made, and much of the research and development had been completed. In its later role as the ELDO first stage, it was fired successfully several times from the Woomera (Australia) launch range. Britain thus has in Blue Streak a relatively large vehicle which has been fully tested and the costs of which, for the most part, have been absorbed. The consequence of this has been, over the years, a variety of proposals, particularly from British industry, for large boosters consisting of Blue Streak as the first stage, with smaller British boosters such as Black Knight or Black Arrow for the later stages. It seems likely, however, that whatever advantages accrued to Britain as a

result of the availability of these boosters at the beginning of the 1960's will end with the passage of time and developments in other countries.

In Britain, as in France, there also has appeared a strong interest in the development of a smaller national satellite booster to complement joint ELDO projects and lay the groundwork for a more advanced national effort. In Britain this involves the development of the Black Arrow vehicle, capable of placing about 250 pounds into a 310-mile circular polar orbit from the Woomera launch site. The Black Arrow, with a first-stage thrust of about 50,000 pounds, is not a particularly expensive venture because it is based on the already proven Black Knight vehicle, which was developed in the 1950's as a re-entry test vehicle for the Blue Streak. The Black Arrow could, like the Diamant B and Scout, become a small but useful national "work-horse" booster.

Balancing Britain's strong technical capabilities is, of course, a generally adverse economic and political environment. Britain's recurrent economic crises do not appear to favor any marked increase in expenditure for space activities, and there has been a general lack of public enthusiasm about national space programs. It seems more likely, therefore, that Britain will undertake independent efforts sparingly, and continue to cooperate closely with the United States in major programs, particularly in communications satellites. Britain, as an international crossroads for trade and commerce, has been especially aware of the potential value of satellite communications. It has been an active partner with the United States in the International Telecommunications Satellite Consortium (Intelsat) effort in the civilian area and, in the military field, in the Interim Defense Communi-

cations Satellite Program (IDCSP).

West Germany

West German space activity to date has been characterized by highly ambitious and advanced feasibility studies, balanced by a relatively low level of development or construction of hardware and systems. For a number of political and technical reasons, the most important of which are probably the restrictions and political sensitivities attendant on German national booster development, plus the lack of suitable national launch sites, the West German space program has been based primarily on multilateral cooperative ventures. Of particular importance is the ELDO program, for which West Germany is supplying the third-stage booster.

Space expenditures of the West German Government have been slowly increasing but still represent only about one-twentieth of 1 per cent of GNP. Of the approximately $60 million per year spent by West Germany for space research and development in the late 1960's, about 60 per cent was committed to ELDO and ESRO. However, running parallel to pressures within West Germany for greater military autonomy, there has also been a certain amount of pressure from the West German scientific and industrial communities to allocate a much larger share of the total space budget to purely national efforts. The following trends in the West German space effort are apparent: (1) the national space effort, in future years, is likely to receive a larger share of the space budget than it has previously; (2) projects considered to provide spin-offs of technology to the national industry and economy will be stressed; (3) there will probably be no attempt to compete in the construction of large boosters. (This last trend, if followed,

will tend to limit the German effort to programs which depend on foreign launch vehicles.)

Government funding is being provided to a number of projects such as: the expansion of existing test installations and creation of new ones; high-altitude research rockets, highly advanced conceptual studies on manned recoverable boosters; and the research and development program for the third stage of the ELDO boost vehicle.

Although the size of the West German aerospace industry is small in comparison with Britain and France, there has been a general policy of maintaining a group of highly talented technical personnel conversant with the latest aerospace technology, primarily by means of bilateral and multilateral arrangements. West Germany has, therefore, become a sort of international center for a consideration of advanced aerospace concepts. Although it seems unlikely that West Germany by itself will initiate any space programs of major significance by the mid-1970's, it could nevertheless be a partner, and possibly a catalyst, in many important cooperative arrangements.

West Germany is particularly restricted with respect to launch facilities, since a site suitable for large rockets is not available on its national territory. Italy has made the Sardinia range available to Germany for the launching of research rockets, and the French Guiana range may eventually be available for German use. Another possible recourse would be a mobile marine platform of the Italian San Marco type.

Finally, it should be noted that the West German GNP is the third largest in the world and is growing rapidly. In spite of present political, geographic, and technical limitations, the German space effort could, perhaps

beginning in the late 1970's, become a far more influential element than it is today.

Japan

The leading industrial nation of the Far East, Japan also has one of the highest economic growth rates in the world. In space, as in many other fields of industry and technology, Japan has shown remarkable progress in the last decade. Although it is difficult to estimate Japan's future course in space, planning in the late 1960's calls for an orderly and ambitious program of about two scientific satellite launches per year.

Since the mid-1950's, Japanese scientists, particularly those at the University of Tokyo, have succeeded in conducting a program to develop large solid-fuel rockets on the basis of an extremely small budget and a minimum of formal organization. From the outset of the effort at the University of Tokyo in 1955, the Japanese rocket program has been based on solid fuels. With the exception of one of the four stages of the Mu-4 rockets, all of the launchings in the University of Tokyo series have used solid-propellant boosters. The Japanese Science and Technology Agency, which will in future direct the main Japanese efforts in rocket development, is also planning to use solid-fuel vehicles.

The most important programs in the recent past were in the Greek-letter series of sounding rockets developed by the University of Tokyo, notably the Kappa, Lambda, and Mu rockets. The first launch in the Kappa series took place in October, 1956, after which successively larger vehicles were developed at intervals of one to two years. The Kappa-8 rocket, launched

in 1960, was able to lift a payload of 77 pounds to an altitude of 125 miles. In late 1963, the Lambda-2 rocket, a two-stage booster 53 feet long, lifted a payload of 405 pounds to an altitude of 255 miles. In July, 1964, the Lambda-3 three-stage rocket raised a payload of 308 pounds to an altitude of 620 miles. The program culminated in the development of the Mu-4 vehicle. The first stage of this rocket made a successful unguided flight test in October, 1966. It was scheduled in 1967 or 1968 to put a 154-pound payload into orbit.

The Japanese Government has a strong interest in satellite applications, as evidenced by plans being developed not only in the Science and Technology Agency, but also in the Ministry of Education, the Meteorology Agency, and other sections of the government. If present planning is implemented, Japan will place its own geostationary communications satellite in orbit by 1973. Although the press and public will probably continue to oppose any programs with military overtones, there appears to be general support for satellite applications for commercial and economic purposes. Furthermore, Japan has very strong technical and economic capabilities to support a much larger effort.

In the past, Japanese rocket specialists, particularly the group at the University of Tokyo directed by Dr. Hideo Itokawa, were able to make great strides in the construction and launching of sounding rockets with a very small budget and without the necessity of technical assistance from abroad. However, the several failures of the University of Tokyo team in 1966 and 1967 to launch small, 57-pound satellites into orbit may indicate that a point has been reached in Japanese rocketry at which larger expenditures

and the importing of foreign technology will be necessary to obtain the larger goals that have been specified. This may, in part, explain the creation of the Science and Technology Agency, which with its potentially closer ties to Japanese industry could undertake space activities on a larger scale. It also helps to explain the increasing concern in Japan about the level of expenditure on research and development and the emergence of the "technology gap" as an issue in Japan as well as in Western Europe.

Communist China

Although the launching by Communist China of a small satellite seemed an imminent probability in the late 1960's, it was equally clear, from available economic indicators, that it was not on the verge of becoming a major spacefaring nation unless it was prepared to curtail somewhat its intensive military procurement. The launching of a satellite offers to an ambitious but secretive hierarchy a way of demonstrating its technical prowess without the need for direct foreign intrusion. The size and characteristics of the satellite are less important than the mere fact of the launching. It seems likely that the most sophisticated applications of space technology in the 1970's will not be made in Communist China but in Japan. Nevertheless, it is entirely possible that future Asian space activity will have its own special bipolarity between Communist China and Japan, and perhaps some of the same characteristics of rivalry earlier seen between the United States and the Soviet Union.

SPACE TECHNOLOGY IN THE DEVELOPING WORLD

Some of the more advanced developing countries were, in the late 1960's, beginning to engage in space activities using technology imported from the United States, the Soviet Union, and Western Europe. Typical of this group are India, Israel, Argentina, Brazil, and Pakistan. Most of these countries are developing national facilities at which sounding rockets, either supplied from abroad or developed indigenously with foreign help, are being launched. In addition, scientific research and experimentation are in progress, and the interest in development of future space capabilities is great. None of these countries is likely to be a major factor in space activity before the end of the 1970's, but it is worth noting that this class of nation is continuing to press hard in the development of sounding rockets.

There is inescapable military significance in the diffusion of rocket technology to this group of more advanced developing countries. Two recent examples are Israel and India. Early in 1966, it was confirmed that French aerospace companies were cooperating in research in Israel which involved the transfer of data on the Topaze research rocket developed by the French SEREB consortium. There were indications in the press that the project might be as much military as civilian in nature. It is obviously very difficult to draw distinctions in cases of this kind between military and civilian cooperation. Under the umbrella of civilian arrangements for the exchange of personnel and scientific data, it becomes considerably easier to shield military-related transfers of technology from the direct glare of publicity. As the Israeli case suggests, civilian agreements can, under

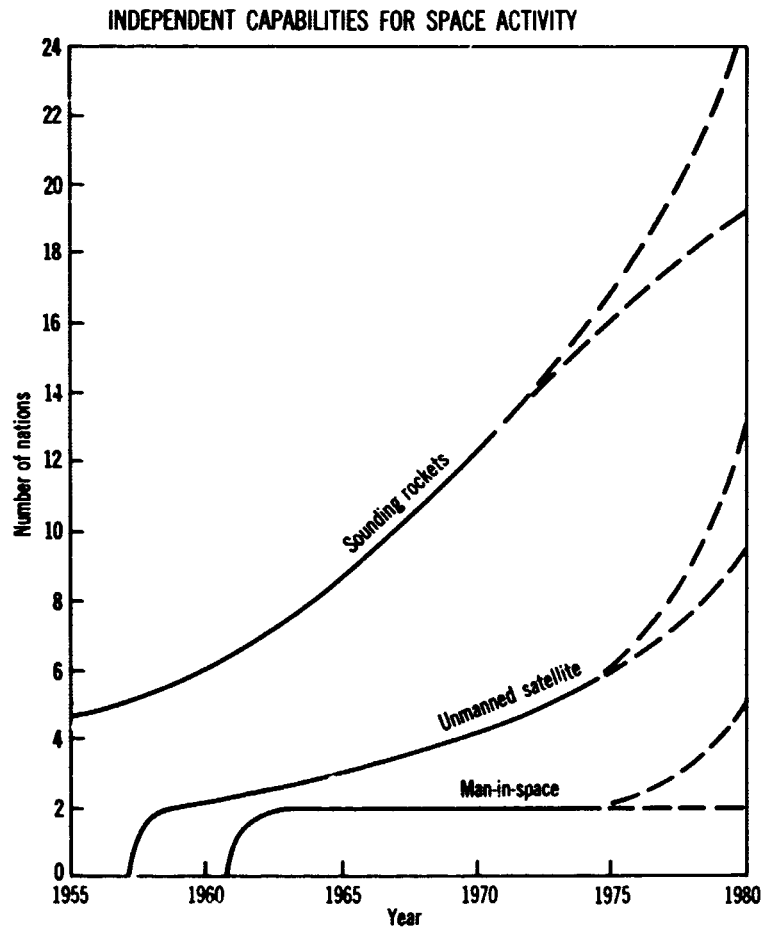
some circumstances, permit missile specialists of different countries to talk with one another, transfer data, or even carry out development and test programs. Even when the programs have no covert military purposes, they may still serve to advance military capabilities to some degree.

Similarly, the Indian Department of Atomic Energy and the French National Space Agency (CNES) entered an agreement in 1964 under which India began the licensed production of French Centaure solid-propellant sounding rockets. By 1967, India had set up facilities to produce the air-frames, propellant, and electronic systems of this rocket. Partially on the basis of French support, the Indian government in 1965 approved in principle a project to build an all-Indian rocket. The possibility certainly exists that this type of activity may provide the means by which indigenous personnel can gain experience which may ultimately be useful in the development and manufacture of ballistic missiles.

The chart that follows depicts an estimate of how rapidly independent national space capabilities may be created. The sharpest rise is likely to be in the field of sounding rockets, which will also have the greatest military significance because of the close relationship between sounding rocket and missile technology. It is possible that as the suppliers of sounding rockets--including both hardware and technology--proliferate in future years, the development of ballistic missiles of moderate range will become more feasible in the developing world. The majority of sounding rockets exported to date have little or no direct military application. The Japanese Kappa-8 rocket, for example, would be capable of lifting only a 77-pound payload a relatively short distance. The inertially-guided French

Topaze, on the other hand, in its present configuration, could probably deliver a 1,200-pound warhead over a range of about 100 nautical miles.

In spite of this one important negative feature, there is no question whatever that space technology can offer important benefits to the developing countries through such direct applications as earth-resources observation, geodesy, meteorology and--perhaps most important of all--communications. But these applications will have to be made primarily through the programs of existing spacefaring nations, because they are obviously beyond the means of the developing world.



The U.S. Government has been particularly sensitive to the problem of missile-related transfers of technology and hardware. In cases where it has supplied sounding rockets to some of the more advanced developing countries, the launches normally have been supervised by American personnel, and the main responsibility of local personnel has been in the design and utilization of the payload. In several of the developing countries, NASA operates ground stations of various types. Although local personnel are invited to apply for positions at these stations, there is usually no opportunity for any technology exchange of real national significance to the host country. It seems likely, therefore, that the economic and other nonmilitary benefits of space technology will be felt in the developing countries mainly through purposeful programs, by the principal spacefaring nations, to apply those technologies directly or indirectly to specific needs.

IMPLICATIONS

The implications of the spread of space technology are vast. It would be presumptuous to attempt in this short chapter to catalog all of them, and only a few specific implications are discussed, some of which have already been identified in the preceding sections. Although the list is obviously not a complete one, it should at least serve to illustrate the importance of the problems and opportunities created by the spread of space technology.

The Technology Gap and the Spin-off Question.

As noted at the beginning of this chapter, the apparent inability of the advanced industrial nations of Western Europe to keep up with techno-

logical developments, particularly in space-related fields, is a major cause of a sense of frustration and apprehension commonly subsumed under the label of the "technology gap." This gap is hard to define or measure, but that there is a gap of some kind, and that it is likely to persist well into the 1970's, appears certain.

One aspect of the gap is the heavy investment in Europe by American industry, which the Europeans fear will mean ultimate loss of control over their own economic resources. This may, in fact, be the most serious manifestation of imbalances--technical and financial--between Europe and the United States in the long term. Europeans argue in part that the heavy investments in defense and space fields in American companies by the U.S. Government greatly contributes to the financial and technical ability of these firms to invade European industry.

More immediately related to technology itself and to the future spread of space technology is the argument that increased investment in space activities is a way of force-feeding technologies, skills, and management practices into national economies. This argument stems from the belief, fostered strongly by the internal U.S. debate over funding for the space program, that there are important commercial spin-off effects from an investment in space. The evidence for such spin-off is sparse at best, but it undoubtedly will play a role in the space policies of many nations.

The "brain-drain" phenomenon is also directly relevant, for no nation can accept as a permanent phenomenon the emigration of substantial numbers of its best scientists and engineers each year. Though both the causes and the statistics are uncertainly known, the primary reason for the migration

to the United States appears to be simply that there are greater opportunities for scientists and engineers in that country. It is usually assumed that the role played by the space program in creating those opportunities is obvious. In fact, the reasons go deeper, and seem to be directly related to the flexible and open relations among universities, government, and industry, coupled with the substantial government investment in science and technology as a whole.

All of these factors, when combined with elements of pride and nationalism sensitive to a second-class status in one of the endeavors that sets this century apart from all others, cause considerable anguish to other nations. Moreover, such factors increase the pressure for the development of independent, national space programs. As was the case with atomic energy in some countries, this pressure, which is likely to become more pronounced in the future, could in fact lead to the relative neglect of other channels for investment of resources that are likely to be more economically productive. For the Europeans to attempt to match the United States in space and atomic energy would, in effect, be playing to America's strong suit. A much more fruitful policy would be to challenge the United States in those areas of technology that it neglects, which are many.

Another noteworthy feature of the Atlantic technological community closely related to the spread of space technology is its high degree of technological interdependence. Even in cases where the climate on both sides of the Atlantic has been cool to technological transfers, such as in technologies related to French ballistic-missile development, the ties are very strong. In the space program, several important production licenses have been

granted by U.S. companies to France in the fields of materials, tracking radar, and guidance. An agreement was signed in 1962 between the U.S. firm Rocketdyne and Sud Aviation under which the technology of wound-filament glass fiber motor casings was transferred. Vascojet steel has presumably also been produced in France under U.S. license--to Vanadium Alloys Steel Company. The missile-tracking stations at the French Colomb-Bechar and Hammaguir ranges used AME (Angle Measuring Equipment) and DME (Distance Measuring Equipment) constructed by the Compagnie des Compteurs under license to the U.S. company Cubic Corporation. Under a licensing agreement with the Kearfott Division of General Precision Inc., the French organization SAGEM has been producing inertial-guidance instrumentation such as floated integrating miniaturized gyroscopes and stabilized platforms.*

In addition to formal arrangements of this kind, a great deal of technology is transferred through personal contacts, visits, and publications. As one French journalist wrote in 1965, "the Americans, whether voluntarily or not, furnished precious assistance to the French technicians [in] the difficult and delicate field of all-inertial guidance."** Undoubtedly, this kind of low-level assistance to France and other nations is likely to continue permanently.

Space Technology for the Developing World.

For the developing countries, the economic payoffs of heavy investments of their own in space are very questionable. However, there are likely to be important economic development uses of space systems provided by the

---

*See Judith H. Young, "The French Strategic Missile Programme," Adelphi Paper No. 38, The Institute for Strategic Studies, London, July, 1967.

**Roger Cabiac, "France: Bon Resultats en Matière d'Engins et d'Espace, Mais," Aviation Magazine International, December 1, 1965, pp. 8-9.

space powers. Resource mapping, low-cost communications, weather forecasting, and educational television programming have already been mentioned. These capabilities are rudimentary or nonexistent as yet, but may hold great potential. To make use of these systems, however, will require the development of indigenous capabilities for research and experimentation (especially in the educational television area) which in turn would require extensive technical assistance.

On the military side, there is the important fact that sounding-rocket and missile technology are closely related. The imperatives of this relationship led the United States for a time to hold back on the sale of small rockets useful for scientific payloads--such as the Scout--to other nations that might also develop nuclear weapons. The difficulty and ultimate futility of such a policy of a total ban on the export of technology have led to modifications in policy. But even today the United States attempts to control the end use to which rockets will be put by buyers, and exercises considerable restraint on the export of information about rocket and rocket-fuel technology.

In the long run, the United States will probably not be able to prevent the development of independent rocket technologies applicable for both peaceful space exploration and for military purposes. Indeed, Britain, France, Japan, and possibly Communist China have already achieved such independent capabilities; others such as Germany, Israel, and India have the potential. For those nations with nuclear aspirations, as well as for those who already have such weapons, a missile-delivery capability is a requisite for an effective strike or deterrent force. Thus, if contingent nuclear

options are to be kept open--even among nations that have signed the nuclear nonproliferation treaty--options to obtain delivery systems must also be kept open. Any nation that might even contemplate some day having to build nuclear weapons can be expected to engage to some degree in space programs.

It is also likely that some countries that achieve independent capabilities in booster technology will seek export markets for their hardware and technology, especially in the developing world, where sounding rockets may have strategic rather than merely tactical applications. Whether such "space proliferation" can be controlled, regulated, or banned altogether is a difficult question. The history to date, in which several countries were able to develop their own technology with very limited American or Soviet help, implies that any meaningful control will be exceedingly difficult without the creation of a powerful international inspection and control mechanism. Japan has already in fact exported sounding rockets to Indonesia and Yugoslavia.

Competition in Commercial Applications.

There are other important present or potential effects in the economic realm. One is the competition likely to occur in the commercial exploitation of space. The United States has been the first to capitalize on the commercial potential of communications satellites. Through the ComSat Corporation, and ComSat's leading role in Intelsat, the United States has assumed a dominant role in this technology.

But this has met opposition, sometimes bitter, from other countries. In particular, the French appeared to be anxious to develop alternative

systems, at the very least to improve their bargaining position for the negotiations on renewal of the Intelsat agreement in 1969. Accordingly, France in consequence has been exploring the Symphonie system with West Germany, as described earlier. Other countries have from time to time explored the possibility of an independent European communications satellite system. Canada has expressed an interest in purchasing ELDO vehicles for launching its domestic comsats, and the availability of the vehicles after 1970 may be of some importance.

The Soviets already have an operating domestic system, which presumably could be extended to international coverage if they decided to challenge U.S. dominance in this field. The United States has been adamant in holding that only one communications satellite system is needed or makes economic sense. But there has been a mounting sense of grievance over the extent of U.S. dominance and control in this field, and by the late 1960's it was not at all clear that the United States would be able to continue the Intelsat monopoly under ComSat dominance. Nor, however, was it clear what the economic and political significance of competing systems would be.

Another important and commercial effect of the spread of space technology that began to appear in the late 1960's was the competition for markets for the supply of component space systems. This international market until then was dominated by the United States and this seemed likely to continue. But the Japanese had already made inroads with their excellent and low-cost technology, and in time others such as France and Germany may do so. If space programs continue to grow, the market for components will become substantial, providing an added incentive for those countries able to mount a meaningful export capability.

Oligopoly in the field of component technology has a political meaning: if a major industrial power is in the position of wanting to limit a space program in another nation, or group of nations, or of threatening to do so for bargaining purposes, control of the necessary components can be a useful lever. This may have been the case in the French communications satellite program because of the latter's dependence on American-made traveling-wave tubes. Component control is a difficult weapon to use, however, and could rebound in other areas. The mere fact that the possibility exists, however, doubtless added to the frustration of France and perhaps others.

The Central Strategic Environment.

Finally, there can be little doubt that the late 1960's are witnessing an increase in the strategic importance of space to the Soviet Union and the United States. The Soviet Union made it clear, through the public displays of its missiles in 1965 and 1967, that it intended to maintain a relatively hostile military space posture, particularly through the development of suborbital or orbital bombardment systems within the limits set by the Outer Space Treaty.* The United States is committed by its policy declarations and treaty obligations to avoid an arms race in space and to promote arrangements to preserve the peaceful character of space, within the limits imposed by national security considerations. If the Outer

*The Treaty does not prohibit, for example, the development, display, or ground deployment of orbital bombardment systems but only their placement in orbit.

Space Treaty is accepted as a worthwhile statement of objectives, then it seems appropriate to lay the groundwork of international compliance at the earliest opportunity. Certainly the competence of Western Europe and Japan could be enlisted for advanced research in space applications useful for inspection and control of space activities. Example might be in preliminary design studies and development of concepts for space inspection vehicles and systems, or in the creation and maintenance of ground space tracking networks and comsat systems to support an international space inspectorate.

The Need for International Cooperation and Control.

It would be a mistake to focus only on the problems and dangers inherent in the increased proliferation of space technology. For such proliferation, accompanied by the desire of more nations to participate, can also create opportunities for achieving positive and constructive policy goals. The very functional need for international control and regulation of space systems to prevent interference, encourage compatibility between systems, and prevent irresponsible use of space, could lead to the development of strong new international mechanisms whose importance could extend well beyond their primary functions. They might contribute to the capability of broader international peacekeeping agencies for example, or serve in other ways as devices to strengthen the United Nations and its role in making space activities more rational.

A general upgrading of space capabilities will also increase the opportunities for international cooperation in space exploration and in the applications of space technology for peaceful purposes. Such cooperation

can have its political rewards in terms of improvement in bilateral relationships or in supporting multilateral groupings.

Many other opportunities for space cooperation remain largely unexplored. In particular, possibilities for multilateral cooperation under U.N. supervision or even management have been scarcely touched. Such cooperation is not without its costs, as the experience in ELDO can bear witness.

But other examples of cooperation, such as ESRO and the high-energy physics laboratory at CERN, have been much more successful. The ELDO lesson demonstrates that the problem is difficult, not that it is impossible. The difficulty of multilateral cooperation must be weighed against potential political benefits, especially in the light of long-term needs for more practical, efficient, and powerful international machinery.

Whatever the pattern that is followed, the possibilities for international space cooperation will grow, along with the proliferation of space technology. It is eminently clear that both developments will open up new political problems--and new opportunities--for the major space powers and particularly for the United States.