# Appendix C
# INTERNATIONAL INVOLVEMENT IN A CIVILIAN "SPACE STATION" PROGRAM*

## Introduction

The National Aeronautics and Space Act of 1958, as amended, includes the following passage: "The aeronautical and space activities of the United States shall be conducted so as to contribute to . . . the following [objective]: . . . Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof . . . ."[1] As a result of this provision, NASA has a long tradition of cooperation with other countries in space activities.

In accordance with this tradition, there have been extensive discussions over the past 2 years between NASA and other friendly countries regarding a possible international in-space infrastructure acquisition program. Then, in January of 1984, President Reagan in his State of the Union Address called for a U.S. "space station" with international participation. These circumstances indicate the importance of a full consideration of various international options for development, acquisition, operation, and use of future long-term, in-orbit infrastructure. The aim of this appendix is to contribute to this consideration.

## Why International Involvement?

### THE MOTIVES FOR COOPERATION

**Countries** engage in international cooperation in scientific and technical undertakings for a variety of reasons. In order to assess the potential advantages and disadvantages of international involvement by another country in a U.S. "space station" program (or even the advantages of fully internationalizing the program) it is first of all necessary to understand the reasons which lead nations to engage in international technical cooperation in general. These motivations can then be discussed as they apply to the specific situation of space infrastructure development, operation, and/or use in order to provide a framework for examining various degrees and forms of potential international involvement, from no involvement at all up to and including a space infrastructure enterprise which is fully multinational from the start.

There are both symbolic and utilitarian payoffs which lead a country to engage in international involvement in its technical activities through formal cooperative agreements. Among the national objectives served by such involvement are:[2]

1. **Symbolic Objectives**
   a. ***political and policy influence–a*** country may engage in international cooperation in order to influence political attitudes and policy outcomes in cooperating countries, in particular so that those attitudes and outcomes are compatible with its own national objectives.
   b. ***policy legitimization–a*** country may invite others to cooperate with it in order to enlist their support for a particular course of action that the country intends to pursue; broadening the base of involvement in a particular undertaking may increase its legitimacy both at home and abroad.
   c. ***policy commitment–a*** country may allow others to participate in one of its undertakings as a means of gaining their commitment to support some of its other policies.
   d. ***leadership–a*** country may invite others to join it in a common undertaking because it believes that such an intimate partnership will allow it to demonstrate clearly to others a leadership position.
   e. ***cooperation to encourage cooperation—a*** country may initiate or enter into a specific cooperative undertaking in order to demonstrate its commitment to the general principle of international cooperation as a desirable course of action.
2. **Utilitarian Objectives**
   a. ***division of labor and sharing of costs–a*** country may invite others to join in an undertaking it wishes to pursue in order to achieve a necessary or desirable sharing of the burdens, particularly the cost, of that undertaking.
   b. access ***to foreign resources—a*** country may open one of its undertakings to foreign participation in order to engage or have access to

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[1] National Aeronautics and Space Act of 1958, As Amended, Section 102(b)(7).

[2] This statement of objectives is adapted from Stephen M. Shaffer and Lisa Robock Shaffer, *The Politics of International Cooperation: A Comparison of U.S. Experience in Space and in Security* (Graduate School of International Relations, University of Denver, 1980).

unique or superior resources, both physical and human, available only in other countries.

c. economic influences-a country may invite others to participate in an undertaking **in order to increase the likelihood that** they will then purchase the products or services of that undertaking, rather than those of potential competitors.

This breakdown of the objectives of cooperation basically reflects the perspective of a country seeking to involve others in its activities; however, it also can be used to identify the reasons why others would agree to cooperate with that country. In general, one would expect those responding to a cooperative initiative to give highest priority to utilitarian benefits, but the symbolic payoffs from international cooperation can accrue, though not evenly, to all partners.

The United States has made international cooperation in science and technology—in space as in numerous other sectors-a major element of its foreign policy; most observers agree that the overall benefits of such cooperation in both symbolic and utilitarian terms have been substantial, and that the negative impacts have been comparatively insignificant.[3] Unless it begins a technical undertaking for motivations which are overwhelmingly nationalistic in character (e.g., Project Apollo or the Supersonic Transport) the United States has welcomed the participation of its closest allies. As international involvement in the "space station" program is assessed, this "bias" toward cooperation will be maintained.

## INTERNATIONAL COOPERATION IN SPACE: THE RECORD TO DATE

In the 25 years that the United States has had a Government-funded civilian space program, international cooperation has been one of its major themes; as mentioned above, it was an explicit objective of the NAS Act. Armed with this legislative mandate, with Presidential and congressional support for a U.S. civilian space program which emphasized openness and scientific objectives, and with already existing patterns of cooperation in space science, NASA has since its inception conducted an active program of international partnership.

**In** space, perhaps more than in most areas of international science, it has been the policies and initiatives of the Government, rather than those of the scientific and technical community, which have established the U.S. attitude toward cooperative undertakings.[4] Although NASA's international programs have involved the Soviet Union, Canada, Japan, and various developing countries, NASA's primary cooperative partner to date has been Europe—both individual European countries and the various European space organizations which have existed over the past two decades.

International cooperation in civilian space activity is thus a longstanding tradition, especially in the field of space science, but also to some extent in space applications and space technology programs. As the general space policies of potential international partners in a space infrastructure acquisition program are reviewed, many examples of cooperative ventures can be brought to light. These range in scope from modest participation in minor projects to intense involvement in major undertakings on the basis of full partnership, An extreme example of the latter is the setting up of an intergovernmental consortium to carry out comprehensive programs in a particular technical field—telecommunications.

On the other hand, there are few examples of substantial involvement of foreign partners in programs which could be characterized as the main thrust of the national space policy of a given country, whether it be the United States, the U. S. S. R., or any other space-capable state. As a matter of fact, the only instance so far of such an arrangement is the involvement, since the early 1970s, of Europe and Canada in the development of the American Space Transportation System (STS).

But even that example is not really valid, since the hardware developments assigned to Europe (Spacelab) and Canada (the Remote Manipulator System, RMS), although producing valuable complements, involve a rather minor share of the total costs involved, on the order of 10 percent. Furthermore, what is really central in the STS is the American-built Shuttle. The other two items are accessory to it: the RMS could easily have been replaced with some U.S.-designed equivalent, and, if Spacelab did not exist, the STS

[3] The Nat tonal Academy of Sciences has recently undertaken a review of scientific and technological cooperation among the OECD countries which reaches this conclusion.

[4] Another area where Government initiatives were crucial in establishing patterns of international cooperation was nuclear energy.

would still be able to carry out 90 percent of its intended activities. s

An invitation for international participation in a U.S. "space station" program might well have the result, as did the U.S. offer to **participate** in STS development, that foreign participation would be somewhat marginal in terms of both the scope and the nature of its share in the workload. A different outcome, however, is also possible, resulting in what was described above as a rather unusual circumstance: major foreign involvement in what will be the brunt of the U.S. effort in space over the next decade or more. Since the early seventies, space technology has been disseminating and/or maturing throughout the world, bringing certain countries almost to par with the United States in aspects of space technology relevant to a such an undertaking, and thus broadening the technical base for significant cooperation.

**In order to understand which of these outcomes is likely and/or preferable, it is first necessary to detail the objectives which would lead both the United States and other countries to collaborate on a space infrastructure undertaking. As NASA's current Director of International Affairs has observed: "International space cooperation is not a charitable enterprise;** countries cooperate because they judge it in their interest to do so. "[6]

## U.S. OBJECTIVES AND INTERESTS RELATED TO INTERNATIONAL INVOLVEMENT IN A U.S. SPACE INFRASTRUCTURE ACQUISITION PROGRAM

In the first year of its existence, NASA formulated a set of policy guidelines for international cooperation in space. Those guidelines have survived periodic reexamination and remain in force today. They reflect "conservative values[7]" with respect to the conditions under which cooperation is desirable.

The essential features of NASA guidelines are:

- cooperation is to be on a project-by-project basis, not on a program or other open-ended arrangement;
- each project must be of mutual interest and have clear scientific value;
- technical agreement is necessary before political commitment;
- each side bears full financial responsibility for its share of the project;
- each side must have the technical and managerial capabilities to carry out its share of the project; NASA does not provide substantial technical assistance to its partners, and little or no U.S. technology is transferred; and
- scientific results are made publicly available.[8]

These guidelines have occasionally been bent, as in the case of the 1975 U.S.-U.S.S.R. Apollo-Soyuz Program. In general, however, they have provided an effective framework within which NASA has pursued a mixed set of objectives, including:

- Scientific/Technical
  - Increasing the number of qualified people working on problems of space research and space technology by broadening the base of involvement in space activities;
  - Shaping the development of the space programs in other countries by offering attractive opportunities to join with the United States in "doing things our way"; and
  - Channeling the funds and technical capabilities dedicated to space in other countries away from activities which are competitive or not compatible with U.S. interests, but involving them in a program dominated by and largely defined by the United States.
- **Economic**
  - NASA estimates that it has achieved over $2 billion in cost savings and effective contributions from its cooperative programs over the past 25 years; cost-sharing has been an influential, though not top-priority, element of NASA's cooperative programs.
  - Involving other countries in expanded space activities may create new markets for U.S. aerospace products.
- **Political**
  - NASA's international cooperative programs have been designed to present a positive image of the United States to our cooperating partners; in particular, the contrast between

[5]The U.S. policy, as became clear in 1972, was to ensure that foreign contributors to the STS should not have responsibility for any element which was essential to the success of the system. The only civilian space programs to which Europe has contributed or is contributing essential parts are the International Ultraviolet Explorer (IUVE) and the Spxe Telescope (ST). There is a strong push within NASA to lim it the foreign role in any "space station' program to non-essential elements, but this push is being countered by an increasingly strong insistence, from the major ESA contributors at least, that potential partners be allowed to develop some of the key infrastructure elements, Of course, there is a natural resistance within U.S. industry to seeing foreign organizations provide what it could produce: witness, for instance, the Industrial opposition to the Canadian development of the RMS. It should be noted, however, that NATO partners are frequently given responsibility for developing essential components of defense systems, with consequent strengthening of the alliance.

[6]Kenneth S. Pedersen, "International Aspects of Commercial Space Activities, " speech to Princeton Conference on Space Manufacturing, May 1983.

[7]Arnold Frutkin, *International Cooperation in Space* (Prentice-Hall, 1965), p. 32.

[8]Shaffer and Shaffer, *op. cit.*, p. 18

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U.S. openness and Soviet secrecy with respect to space has been exploited by the United States.

— International cooperation in space has been undertaken by the United States in order to advance other U.S. foreign policy objectives.

While the priority given to these various objectives has varied over time and mission opportunity, at the core has been a policy that permitted this country's closest allies to become involved in the U.S. space effort. Indeed, some have criticized NASA for making possible such participation, at minimal cost, in an effort paid for almost entirely by U.S. taxpayers; "benefit, know-how and opportunity were shared to an extent which was totally unprecedented where an advanced technology was involved . . . ."[9] Since the start of its civilian space program, the United States has used international cooperation in space as a means of creating a sense of togetherness and common achievement among, particularly, the industrial democracies which are this country's most significant partners in maintaining world order.

The benefits to the United States of international space cooperation do not come without costs, of course. Among the potential negative impacts of involving others in the U.S. space program are:

1. increased technical risk and management complexity;
2. Significant out-flows of sensitive or valuable U.S. technology, employment opportunities, and/or hard currency, as the United States purchases space-related goods or services from other countries;
3. in particular, the development, through their involvement in U.S. space activities, of effective competitors to U.S. firms in commercial space efforts; and
4. possible disputes among the United States and its cooperating partners-which, if not resolved, could lead to broader foreign policy conflicts.

To date, NASA has managed its affairs so as to have minimized these potential negative impacts. For instance, many of the cooperative programs involved NASA's launching of foreign satellites, in which the technical risk to NASA was virtually non-existent and which often led to foreign purchase of additional launches.

[9] Arnold Frutkin, "U.S. Policy: a Drama in N Acts," Spectrum, September 1983, p. 74.

## FOREIGN OBJECTIVES AND INTERESTS RELATED TO INVOLVEMENT IN A U.S. "SPACE STATION" PROGRAM

Success in cooperative undertakings requires that each side perceives the cooperation as being beneficial to itself; such undertakings are even more likely to be successful if there is at least some commonality of objectives. All partners must believe that cooperation is a useful means for advancing some of their national objectives without undue costs related to others. It is somewhat more difficult to generalize with respect to the motivations which might lead specific countries or groupings of countries to decide to join the United States in development, operation, and/or use of space infrastructure, but the following seems most germane:

- **Scientific/Technical**

  In most areas of space technology, the United States is still a leader. Other countries may hope that close partnership with the United States will give them increased access to these technologies and help upgrade their own technical capabilities.

  The "space station" contains elements of space infrastructure which, used in connection with the space transportation system, will "modernize" space operations; other countries may decide they must be part of the most advanced way of operating in space,

- **Economic**

  — If the commercial potential of many areas of space activity is as large as some forecast, use of in-space infrastructure will be an essential or at least extremely useful means for achieving that potential. Other countries wanting to participate in the commercial exploitation of space may view sharing the costs of a "space station" program as the best way to be major partners in such commercial exploitation.

  — Cooperation with the United States may be the only way that other countries can afford to develop capabilities in particular areas of space technology. Division of labor and costs is a necessary approach for those without the resources to develop a total system of space infrastructure on their own. While the United States could probably afford to develop it on its own, as could the ESA countries in collaboration with Japan,[10] probably no other coun-

[10] As noted later in this appendix, there is a considerable difference between the amount of taxpayers' money the United States on the one hand and Europe and Japan on the other are prepared to spend on space. But there is little doubt that Europe alone *could* make a comparable investment *if* the political will existed.

try or region except the Soviet Union and its allies could make a comparable investment in space.

- Other countries may anticipate that such a program will provide marketing opportunities for their industries and want to participate in the program in order to maximize those opportunities.

. **Political**

- Participation in the "space station," like participation in the space transportation system, may provide other countries a way of sharing in the political and prestige benefits of manned space flight activities without bearing the total cost of manned systems.
- The United States is the military and economic leader of the non-Communist world; cooperation with the United States in such an effort may provide a way for other countries to maintain or increase their commitment to a political and military alliance with the United States.

## THE POTENTIAL FOR AN INTERNATIONAL "SPACE STATION" PROGRAM

Some have suggested that any major new undertaking in space be from the start "truly" international—i.e., designed, funded, and managed by an international consortium or an equivalent organization .11 Although the current momentum behind "space station" plans is leading away from this option, it is worth identifying it here and assessing it later as a possible way of approaching its development or operation.

Such an approach would, of course, be the ultimate in the way of internationalizing a program; in this mode of cooperation, the United States would merely be a shareholder among many others within a consortium of participants. There are precedents in this respect; an instance which comes readily to mind is that of the International Telecommunications Satellite Organization (INTELSAT).

In 1962, the U.S. Congress passed the Communications Satellite Act, creating the Communications Satellite Corporation (COMSAT) and charging it with developing a global system for international satellite communications. The United States could not achieve such an ambitious goal without the active participation of other nations; therefore negotiations were started which led (after substantial conflict) in 1964 to an "interim agreement" under which a global network was successfully established. In 1969, a Plenipotentiary Conference was convened, with 67 member countries in attendance: it resulted in a Definitive Agreement which entered into force in 1973 and made INTELSAT a working international organization, with a present membership of more than 100 countries.

The U.S.S.R. and other socialist countries never joined INTELSAT, both because it was initiated by the United States and actually run by Americans during the first years of its existence and because they would have had very little influence on the organization under the weighted system of voting which was employed.

The International Maritime Satellite Organization (INMARSAT) has a number of features that are distinctly different from those of INTELSAT. It provides global coverage, whereas INTELSAT does not. Another difference is that among its member states, INMARSAT counts the Soviet Union (with a 14 percent ownership share, second only to the United States' 23 percent) and several other socialist countries. INMARSAT'S statute obliges it to provide free access to members and nonmembers.

INMARSAT was created pursuant to the initiative of a United Nations agency, the Inter-governmental Maritime Consultative Organization, which, from 1973 to 1976, convened a series of international conferences to establish a global maritime satellite communications system. In 1979, the INMARSAT Convention and Operating Agreement entered into force, and operations started early in 1982. With the exception of the above-mentioned differences, INTELSAT and INMARSAT are similar in structure.

Could a similar international organization be created, in order to develop, operate, and use in-space infrastructure? In principle there is no obstacle to this, although the parallel with INTELSAT can be very misleading. In particular, it is not clear that the provision of orbital infrastructure to accomplish a variety of objectives could ever be the kind of profitable enterprise that space-based communications has been. Communications is a well-established business, yielding a return on investment of about 14 percent within INTELSAT. Also, the capability upon which INTELSAT was originally based (communications satellites and launch capabilities) had been developed by the United States at its own expense.

There are no such credible economic prospects for space infrastructure, which would have many different uses, some for pure government-funded research, others in the nature of a public service, and still others for commercial applications. Also, in a satellite communications system, there lies more cash-flow in the procurement of the ground segment than in the building of the satellites. This has made it possible for

11 See, for example, Robert Salkeld, "Toward Men Permanently in Space," *Astronautics and Aeronautics*, October 1979.

American firms to be the exclusive manufacturers of INTELSAT satellites for years without stirring too much resentment within the international consortium, because other member countries have found adequate compensation in the manufacturing of ground stations for themselves and for sale abroad.

Also, Europe, with its Ariane series of boosters, is now competing for INTELSAT launch contracts. In addition, some form of international cooperation was absolutely essential, almost by definition, for an international communications network to be feasible. No such cooperative imperative is attached to space infrastructure.

A more adequate precedent for an international "space station" enterprise might be that of an international organization created to conduct a number of jointly coordinated space programs for the benefit of its member states. Such a "limited partnership" may be a realistic approach to space infrastructure development and/or operation. To a large extent, the European Space Agency (ESA) does provide such a parallel.[12] Since its inception, ESA has performed very successfully in spite of the difficulties associated with almost all international organizations.[13] In ESA's case, the two major problem areas have been, and still are: 1) the time and burdensome negotiations required to settle differences about general policies to follow and what programs to support; 2) the framing of an "industrial policy" designed to improve the worldwide competitiveness of European industry while ensuring a "fair return" to individual members states (the "return" is the value of the contracts let by ESA to any member state, and it is "fair" when proportionate to that member's financial contribution to the agency's budget).

The Convention governing ESA provides some clues as to how these difficulties are dealt with in the long run:

1. The formal structure of ESA is designed to accommodate laborious negotiations and compromises. The legislative power, so to speak, rests with a Council where all states are represented; the Council meets regularly, usually for 2-day sessions.[14] There is also an Executive responsible for day-to-day operations and long-range planning.
2. ESA's overall activity is subdivided into two categories:
   - mandatory activities, which include chiefly scientific programs and basic organizational expenditures; mandatory contributions are based on each state's GNP;
   - optional activities, which are specific programs like Ariane, Spacelab, Marecs, and so on; contributions to these programs are negotiated between the participants at the inception of the program.

This system provides ESA with a considerable flexibility: although unanimous consent of all Member States is needed formally to permit ESA to undertake an optional program, a vote in favor of the program does not carry any obligation to participate. Member States may decide, after a program has been authorized, whether—and, if so, to what extent—they will participate. Thus, Member states can adjust their financial effort to the degree of interest they see in a program and/or to the "return" their industry will obtain from it (one of the solutions to the irksome "fair return" problem). Also, member states can support another partner's favorite project by a token participation which can be traded against others, resulting in "package deals" which settle seemingly unreconcilable differences.

A further degree of flexibility is provided by the fact that the agency is not obligated to manage all of its programs through its own staff. ESA can delegate to a national agency the responsibilities for a program's management, if this appears to be preferable from a political, economic, or technical point of view (CNES, the French space agency, is thus entrusted with technical management of the Ariane development program).

3. ESA early recognized that a multinational agency is better off letting contracts to multinational industrial firms rather than attempting to balance contracts among national companies according to its "fair return" principle. This balancing act is often performed better and more quickly inside multinational consortia of European aerospace and electronics firms, the creation of which ESA has encouraged.

As a last parallel which might be drawn from ESA, it should be noted that this agency's role is generally limited to development and demonstration of space systems. Utilization, in the sense of operational or commercial exploitation, is usually entrusted to other intergovernmental organization, like EUTELSAT for regional European communications or EUMETSAT for meteorological satellites. Commercial operation can even be entrusted to private multinational corporations like ARIANESPACE, which has been established

[12] ESA is described in more detail below.

[13] Indeed, if one takes a long view of past European cooperation, say, over 100 years, ESA's record is strikingly good. Although its operations have been on a much smaller scale than have those of NASA, ESA's record of technical successes is perhaps as good as that of any other organization.

[14] In general, each Member State has one vote in the Council. However, a Member State does not have the right to vote on matters concerning an optional program in which it does not take part. Except where the ESA Convention provides otherwise, decisions of the Council are taken by a simple majority of Member States represented and voting.

to produce, market, launch, and finance Ariane launch vehicles. This arrangement could be paralleled in an international "space station" program: different international entities, with possibly different membership and operating procedures, could take care of its development and operation.

As far as development and operation are concerned, one might question whether the creation of international entities in charge of these activities would entail creation of new technical agencies duplicating the know-how and resources of existing space agencies, most notably NASA. Clearly, this would not be an advisable course. However, the international body in charge of the program could confine itself to overall management, and rely on existing agencies in the participating countries for technical management, supervision, and day-to-day activity, a procedure similar to that sometimes followed by ESA. Given that the United States would undoubtedly be the largest shareholder in such a joint venture, it should be possible to have the leading role assigned to NASA and/or the U.S. private sector in this context. Other major agencies like ESA (Europe), NASDA (Japan), CNES (France), or DFVLR (West Germany) would as a matter of course have to be entrusted with tasks commensurate with their country's or region's financial commitment.

### THE POSSIBILITY OF A U.S. DECISION TO "GO IT ALONE" WITH RESPECT TO THE "SPACE STATION"[15]

Of course, there is the possibility that no other country will reach agreement with the United States to cooperate in the acquisition and use of in-space infrastructure. In this unlikely situation, the United States would "go it alone. " Would such a step deal a fatal blow to all future prospects of international cooperation in space? There seems to be no reason to fear such a drastic outcome: what would probably happen is merely an extension into the future of the present situation, characterized by a large amount of duplication, with most countries striving to acquire more or less the same capabilities so as to be able to compete, especially where commercial applications are concerned.

The same countries, however, are now willing to participate in quite a large number of cooperative schemes, not only in the field of space science (reputedly free of competition), but also in general public service types of applications (e.g., meteorology or search-and-rescue), and even in commercial applications (e.g., communication via INTELSAT, INMARSAT, or INTERSPUTNIK). Cooperation, in other words, seems to be a widely recognized way of performing space activities, provided a certain amount of autonomous assets have been secured to safeguard national independence and ability to compete, so that if this U.S. offer to cooperate is not taken up on a program as central even as the "space station, " this situation is unlikely to be reversed,

That such duplication does not make optimal use of the global resources of the international community is obvious, but by no means new. If one accepts it, the next question, from a U.S. perspective, is whether other spacefaring countries, not being involved in the U.S. program, would thus be motivated to challenge U.S. supremacy in space and to compete commercially with it even more effectively and better than they do now. In other words, what are the implications if other countries strive to acquire more or less the same capabilities as the United States is seeking by developing space infrastructure, but on their own and not in partnership with the United States?

It should be noted first that acquisition of similar capabilities does not necessarily require development of similar technology. The capability to launch satellites, for instance, can be provided by a very sophisticated reusable craft like the Shuttle, or by less inexpensive expendable rockets. Similarly, it could turn out that most or all functions of space infrastructure that utilize a human crew could eventually be performed by one or several automated systems. This certainly seems to be true whenever a single specific activity is under examination: materials processing in space, for instance, could perhaps be adequately performed in an operational production mode by an unmanned platform along the lines of the French SOLARIS concept.

Therefore, when specific activities are considered in isolation, there appear to be ways for other countries to remain competitive in space applications without joining a U.S. "space station" program. However, when looked at from a global perspective, a comprehensive space program is more than the sum of a few specific application projects. U.S. development of long-term space infrastructure would mark the inception of a new way of performing activities in space; the hoped-for result would be enhanced flexibility and economies of operation in many areas of space science and applications, whether already recognized or presently unforeseen.

[15]The circumstances adduced at the beginning of this appendix provide reason to believe that a U .S. -only program is the least I ikely alternative, However, since no final Congressional decision on international participation in any U.S. "space station" program has been made—and since the Congress may wish to reconsider this matter *de novo*—the U.S.-only option is Included here

Any country wishing to gain access to this new way of doing business in space would have to acquire an extensive set of technologies and systems:

1. Orbital communication relays. (The United States is developing such relays in the form of the Tracking and Data Relay Satellites; similarly, ESA's L-SAT will have orbital capabilities and will be used in this role for the control of EURECA).
2. In-orbit servicing (and probably retrieval) systems. (The United States has flown a short-range system of that kind, the manned maneuvering unit (MMU), which enables people to tend satellites in the vicinity of the Shuttle, To go further along this line, NASA will have to develop the so-called Orbital Maneuvering Vehicle (OMV)).
3. The capability of returning space hardware from orbit to the surface of the Earth via unmanned vehicles. (This is a capability which the United States has bypassed through development of the Shuttle) and/or;
4. Ultimately, man-rated launch and reentry vehicles (unless automated systems or systems remotely controlled from the ground suffice. to perform all the space tasks for which the need for human beings is currently foreseen–a possibility which is debatable at best).

Even if one takes into account that such capabilities need not rest on facilities identical (in terms of size, sophistication, etc.) to those deployed by the United States, the cost of their creation is nevertheless likely to be several times higher than the cost of creating and maintaining independent "traditional" satellite building and launching capabilities.

Consider, for instance, the total development and flight testing cost of Ariane 1: roughly $1 billion (1984). The corresponding cost for the Shuttle exceeds $10 billion. The Shuttle's payload capability is much greater than that of Ariane 1, especially in LEO. But the important point is that Ariane suffices to endow European countries with the capability to launch all the applications satellites they need, and even further, to market launch services abroad, competing commercially with NASA and the U.S. private sector in that field. (One might state more accurately that the real competition will come from the Ariane 2, 3 and 4 versions, which together will cost about an additional $400 million beyond the initial development expenditures: the argument, however, still holds true.)

Suppose now that Europe decides to acquire a manned flight capability of its own. A typical way to do that (as explored in ESA's "long-term preparatory program") would be to develop an even larger version of Ariane, with a LEO capability around one-half that of the Shuttle: under the name Ariane s, various preliminary designs for such a vehicle have been publicized. These designs are compatible with a winged reentry vehicle, looking somewhat like a down-scaled Shuttle, which under the name HERMES has also been through early design stages in France. Both craft could operate automatically but could also transport people.

No cost estimates have been officially quoted yet, but independent experts, by extrapolating from other European and U.S. program costs, predict $2 billion to $4 billion as the price for acquiring such a minimal capability. This is much less than what it took to develop the Shuttle, but 2 to 3 times what it cost to develop Ariane. Of course, in order to exploit such a staffed flight capability properly, if it is not to remain only a prestige enterprise, all space activities must be adapted to the "new way of doing business in space." Today's European satellites, for instance, do not lend themselves to servicing in orbit; all sorts of new techniques would have to be adopted for that purpose, such as modules easy to plug out or in; built-in, readily accessible and readable check-out circuits; safety devices destined to protect the astronauts' lives, and so on.

In turn, even if this proves to be economical in the long run, it would call for increased investment at the start. Added to the higher operating costs of manned space flight, the overall consequence of all these considerations amounts to this: in order to acquire the capabilities which go with the new way of conducting space activities, medium space powers like **Europe or Japan would probably have to multiply their space budgets by at least 2 to 3 times. However, the ratio of civilian space expenditures to gross national product** (GNP) in Europe and Japan is much smaller than the corresponding ratio in the United States—i.e., roughly 4 times less. There is therefore room for expansion, but such a major shifting of gears would require a reassessment of national priorities in all the countries involved, and there is no sign that such a reassessment is imminent.

A last question to address is whether another alternative is open to these countries: again assuming that the United States goes ahead alone with the development of a "space station" and all the attendant new technologies, must countries wishing to enter into or stay in the space business of necessity develop similar capabilities? In other words, could "doing business in the old way" be competitive when faced with the "new way, " just as expendable launch vehicles from Europe, Japan, and the United States seem to be managing to stay in competition with a very new and different craft, the Shuttle?

Two factors will have a deciding influence on this question:

1. **Economics**
   - The relative importance of captive markets;
   - charges applied to users: the very sophistication of new systems may, at least in the initial phase, lead to high operational costs; this argument is further complicated by the fact that user's charges do not necessarily reflect actual costs. If the United States decided to go ahead for reasons of its own, not all of which were economic ones, it probably would not fully amortize costs through user's charges; other suppliers of space services might do the same, to facilitate export sales, for instance;
   - the fact that the key area of commercial competition in space utilizes the geostationary orbit, whereas the "space station" and its related new capabilities will at the start focus on LEO activities, and will extend their sphere of operations to geostationary orbit much later; meanwhile, business can go on as usual in that orbit.
2. **Political and Technical Trends**
   - One of the major impacts of "space station" technology will be in the field of construction and assembly of large structures or platforms in orbit. Presently, however, there seems to be a trend in favor of small or medium-sized satellites which fit the needs of one given country or group of countries eager to possess its own independent system. Small to medium-sized satellites would probably also appeal to commercial operators (in the United States and elsewhere) who might find it of advantage to own a system built along their specifications rather than to lease a segment of a larger system.
   - However, even small/medium satellites might benefit from new methods of operating in space. The capability to check a satellite in low orbit before transferring it to its final orbit to start operation there, or the capability to repair it when it fails, may be a significant commercial advantage which no prospective customer is likely to overlook. However, the economic attractiveness of satellite servicing is still a very controversial matter; lb anyway, from a strictly financial point of view, a customer could be presented with the same advantages by an adequate system of warranty. But the psychological appeal would clearly be in favor of the servicing capability.

[16]The reluctance of those concerned to meet the relatively low costs of retrieving and refurbishing WESTSTAR 6 and PALAPA B-2 indicate that in-orbit retrieval and repair are not yet economically attractive.

At the present stage, it would seem that neither economic factors nor political and technical trends yield a clear answer to the question of whether there is an alternative way open to countries unable or unwilling to acquire in-space infrastructure. This is a major reason to believe that the U.S. offer to cooperate with other countries will be accepted by other spacefaring nations, at least to the minimum extent necessary to see what happens. Whether such minimal participation is in the U.S. interest will be discussed later in this paper. But the conclusion of the reasoning and analysis just presented is inescapable—as the United States **begins a space infrastructure program, others will want to be part of it, provided the cost (in all senses of the term) is not too great.**

## Possible Modes of International Involvement in a U.S. "Space Station" Program

There is a wide variety of possible forms that international cooperation in a space infrastructure program might take. This section describes two general categories of involvement, each with several variations:

1. international cooperation during "space station" development, then separate deployment of operational systems; and
2. international cooperation throughout the deployment, operation, and use of the "space station ."

### JOINT DEVELOPMENT, SEPARATE DEPLOYMENT

If the United States and/or its potential international partners believe that free and open competition in utilizing space is preferable (or unavoidable), and if these countries nevertheless want to save on development costs and prevent all-out duplication of efforts, then this option will be attractive. joint development of a total system or a piece of hardware, followed by separate or independent deployment, operation, exploitation and/or sale is a commonplace arrangement in, among others, aerospace programs. Many military and civilian aircraft have been or are being born that way, at least in Europe. The United States seems to favor separate development followed by licensing agreements, but there are examples to the contrary (e.g., the joint development of the CFM 56 jet engine by General Electric and the French SNECMA).

Among the reasons that other countries might want to commit only to joint development, reserving the right of separate deployment of constituent elements, are:

1. Going along to see what happens. This would typically be the attitude of countries or agencies feeling rather skeptical about the benefits to be

derived from use of in-space infrastructure, but which deem it necessary to be at least symbolically present in the game, just in case it turns out that their skepticism was ill-founded. Such partners may not be of the most active sort, but they also will not be troublesome, since the very reason of their being present is "to follow the leader." Presumably they would not be interested enough in the joint undertaking to fund cost increases if the program should meet with difficulties, and would therefore attempt to settle for a fixed amount rather than a fixed percentage type of participation.

2. Going along to acquire some of the know-how and of the technologies to be derived from the program. This would be the attitude of countries or agencies with a positive attitude towards new systems, but which are not in a hurry to deploy and use them, so that they only want to acquire knowledge to be implemented in a much later perspective. Along with other, more "political" motivations, this seems to be what prompted Europe to join the post-Apollo program. There was also a more immediate industrial motivation; Europe hoped to sell to NASA more units of the hardware developed by European firms, and NASA has indeed purchased a second Spacelab flight unit in Europe. This type of motivation is apt to create problems, insofar as it raises the issue of technology transfer or dissemination.

3. Going along in order to & able to deploy a separate system at about the time that the primary partner deploys its own. This is a sign of real interest to the program, insofar as it means that all parties truly believe in it. However, it might well generate more problems than would the preceding ones. It is indeed unlikely that all parties concerned will aim, through their joint development efforts, towards development of strictly identical infrastructure elements. As a consequence, a number of compromises would have to be accepted by all (or some of) the participants to reconcile differing specifications. Any given participant will tend to specify the work assigned to it so that it serves directly (or with the smallest possible amount of modification or adaptation) its own national interests. However, the end product of the same work, if the joint endeavor is to make any sense, must also be readily adaptable to what other participants plan to construct. In a rather grossly exaggerated way, this is a situation akin to ESA and NASA trying to agree on a definition of Spacelab which would enable it to be launched either by the Shuttle or by Ariane.

Such compromises are by no means impossible, but must be evaluated on a case-by-case basis to make sure that the overall cost of the compromise design and of its adaptations to specific needs does not exceed the added costs of separate developments. Furthermore, such a compromise design is inevitably difficult to agree on, for all parties tend to believe that it is to them that will fall the largest amount of modifications to be made later to adapt the common development of their specific needs. These, however, are problems inherent in all cooperative development programs, and past experience, notably in the field of aeronautics and armaments, proves that they can be settled whenever a strong sense of common purpose prevails.

While, for one or more of the reasons sketched above, joint development without a commitment to joint operation or utilization may be attractive to a potential cooperating partner, it would appear that the United States might prefer a more comprehensive cooperative approach, as described below. However, there may be reasons for the United States to avoid commitment to international involvement beyond the development stage. Among such possible motivations are:

1. A feeling that national security applications in space might evolve in such a way that the United States would prefer to deploy its own infrastructure so that it could control access to it; this is not necessarily a problem since provisions for such restriction could be part of an international agreement.
2. A similar argument could be made if, particularly, materials processing activities appear quite promising commercially and U.S. firms prefer a U. S.-only "industrial park" in space.
3. The United States may prefer a safety valve freeing it from the need to continue a joint effort if there is a likelihood that the cooperative experience during the development phase is not satisfactory on technical, economic, and/or political grounds.

In addition to all of the above, dissatisfaction with joint development programs sometimes crops up, not from problems directly related to the development phase of the undertaking, but from an apparent or real lack of benefits deriving from the joint effort once it has carried through. This leads one to examine what benefits can be expected, and what sort of framework is needed to ensure that they can be reaped.

1. Each party deploys and uses for its own purposes one or several units of the jointly developed hardware. (Construction would presumably be shared among industrial firms which built the proto-

types.) This approach is feasible if integrated systems have in fact been jointly developed; however, as stated earlier, this may not necessarily be the usual case, as agencies and administrations involved will tend to prefer clear-cut interfaces rather than closely integrated systems.

2. Assuming then that each participant has developed a self-contained system (e.g., the United States develops a core element and country X a teleoperator maneuvering system (TMS) compatible both with the U.S. element and country X's own spacecraft and launch vehicles), several options are possible:
   - Participants in joint development efforts make no provisions for the post-development phase, and leave it to evolving circumstances and economics to ensure a successful career for the developed items. (For example, if the U.S. elements are sound ones, country X will purchase one or more, and vice versa, provided no legal obstacles or perceived national security concerns regarding these sales arise).
   - Make it an obligation for all par-ties to purchase (and agree to sell) one or several units of the hardware developed by each.[17]
   - And, of course, all possible intermediate arrangements between these two extremes. (To use a simplified example: the United States could be obligated to use country X's teleoperator maneuvering system, not by purchasing it but by offering as a compensation a given amount of "utilization time" on elements of its infrastructure; reciprocally, country X's obligations would be to provide and maintain a given number of these TMS vehicles.)

A "closed-end" international partnership appears to make the most sense if the infrastructure is a" necessary, but not sufficient, part of the capabilities required for effective and efficient operations in space. All partners will want to ensure that whatever is developed will be compatible with their longer range, but separate, plans for space. However, this kind of limited international involvement is less likely in most situations to be attractive either to the United States or to its potential partners than more substantial involvement in the operation and utilization phases as well as the development phase. The following section examines such an approach.

[17] Such an explicit obligation would circumvent the possible unwillingness of one party to purchase elements from another. From the European point of view, U.S. unwillingness to purchase additional Spacelab modules has been something of a problem.

### JOINT DEVELOPMENT, OPERATION AND USE

The essential features of this option are:
- operation and maintenance costs of the infrastructure, as well as development costs, would be shared;
- ownership of most or all of its elements would stay most probably with the United States; however, all participants' rights of access and use for common and/or national purposes, including mutual commercial competition, would be guaranteed by an adequate legal framework.

Implementation of this approach is essentially a three-step process, where each step has to be considered separately before an overall conclusion is made:

1. **Joint Development**

   Most considerations just set forth in the section above are applicable here. In a way, however, there are fewer problems; the ultimate purpose of joint development being the deployment of elements to be used jointly, there is less need for involved legal rules concerning mutual purchasing obligation, second source development, and so on. Nor does one have to be concerned about compatibility of certain sub-elements with individual countries' nationally developed launch vehicles and the like. (Unless of course some participants wish to be able to break the partnership and go their own ways, but this would not be set as a primary objective of the arrangement.)

   Needless to say, though, "rules of the game" are still indispensable, especially in three areas:

   Settling the ownership of technology acquired while carrying out the joint development, and transfer of technology, where required, for accomplishing the work;

   Assuming a dominant position of the United States in the undertaking, how much potential leverage will be left to its partners in order to give them a feeling of being able to protect their rights?

   Conversely, one has to retain for the United **States the possibility to work out substitute arrangements, in the event that one or another of the partners defaults, so as to ensure the ultimate integrity of the program,**

2. **Joint Operation**

   jointly developed infrastructure can be used jointly while being operated by a single country—presumably the United States. joint operation would, however, lend a more international flavor and help international participants to feel more secure by giving them added leverage—

with, of course, potential problems for the United States.

International involvement in operating the infrastructure could range from very little (opening a few positions to foreign nationals on the ground control team and possibly in the orbital crew, as a token gesture) to full-fledged internationalization of both ground team and crew. The latter would imply including citizens of other countries in various key positions in numbers proportionate with the overall level of participation of their country in the program.

The latter case, even if likely to create problems for the United States by the leverage and the visibility it gives to its partners, might, however, also pave the way towards solution of one issue raised by this approach—the question of "equitable costs." Assuming that the United States develops, say, 95 percent of a "space station" system, and that country X develops and builds 5 percent of it, it seems fair to reserve 5 percent of the station's effective working time for country X's purposes. If, however, the United States is alone in bearing all the maintenance and operating costs, X cannot enjoy its 5 percent "space station time" free of charge. Some equitable reimbursement scheme has to be devised for maintenance and operating costs incurred by the United States—a scheme that would resolve attendant problems of fair and accurate accounting, opening U.S. accounts to X's comptrollers, devising rules for taking into account all the fringe benefits built in the system (like the replenishment of propellant tanks with unused fuel from the Shuttle, and so on). However, if country X actually carries out 5 percent of the maintenance and operations in kind, it may be possible to end up with an almost no-exchange-of-funds situation.

3. **Joint Utilization**

The problem here is that there will be not only utilization in common for common purposes, but also an individual participant's use of the infrastructure for its own benefit, including commercially competitive types of usages.

International partners will want to be provided with adequate safeguards to protect their legitimate rights. This, in turn, raises the question of what are "legitimate rights." An effort should be made to define this concept as precisely as possible. Listed below are what appear to be major issues involved:

— Is thereto be unrestricted use of a given fraction of the "space station's" effective work time, for the user's own benefit, for whatever purposes, provided it complies with international law and a preset series of explicit rules? These rules must not be open to unilateral interpretation. Sensitive aspects, such as safety and national security requirements, must be exhaustively and accurately dealt with in advance, so as not to allow, later on, the impression of arbitrarily imposed requirements. This right-to-use may not necessarily be free of charge, but if a price has to be charged for it, it must be equitable (no preference with respect to the U.S. Government or private users, no hidden overheads, etc.). As stated above, the ideal situation would probably be one where very little or no exchange of funds occurs. The setting of utilization priorities is equally important in this connection; the present NASA-DOD arrangement for giving absolute priority to national security payloads in Shuttle manifesting would not be likely to generate much international enthusiasm if it were paralleled.

Cancellation clauses must be very explicit and provide for adequate prior warning and compensation; unilateral recanting should not be allowed. Needless to say, the purpose of such clauses would not be limited to protection of U.S. partners; the latter would have to consent as a counterpart to a perdurable involvement system, in order to allow not only for the infrastructure's initial deployment, but also for the continuous evolution and growth which is going to be one of its main features.

There seems to be no reason why all the above-mentioned issues could not be settled in the terms of a cooperative agreement among the United States and its partners. Legal terms, however, would probably not be sufficient to enable all parties to the undertaking to feel safe and secure: safeguards embedded in the very fabric of the joint effort, providing mutual leverage and affording room for the inevitable compromises, may have to be accepted.

On the surface at least, such a situation might appear unbalanced in the eyes of the U.S. public and Government: the United States will probably be carrying most of the burden of the joint undertaking, and would seem required to provide to others guarantees and safeguards and to accept dependence on them in excess of what would be commensurate with its partners' share of the burden. To most of these partners, however, being involved substantially in a U.S. "space station" program would mean forfeiting their ability to develop not only a similar, but even a reduced, capacity of their own, at least in the near term. Therefore, they will be staking the whole of their initial asset commitment in the joint venture, whereas the United States would always be in a position, with some added funds and efforts, to make up for the failure of one of its partners to keep the deal—a recourse that, under the circumstances, would be more costly to the partners.

From the U.S. point of view, of course, accepting international participants in its "space station" program makes sense only if this apparent–and, to some extent, real—imbalance does not jeopardize fundamental national interests. The more guarantees and safeguards the United States can afford to offer to its potential partners, the more those countries are likely to participate substantially and to pay accordingly. This working out of mutual stakes in a common undertaking is likely to be a delicate and complicated process,

## Potential International Partners

Now that potential modes of cooperation have been discussed, the potential partners for the United States in a "space station" effort will be described in some detail.

Advances in space technology over the last decade throughout the world provide many prospective candidates for bilateral or multilateral cooperation on a space station project. One should, however, keep in mind that taking a meaningful share in a program of such scope, cost and technical sophistication, will be no trivial undertaking for most of these candidates. What is meant by "meaningful share" depends, of course, very much upon the circumstances. In a bilateral arrangement between the United States and another country, the latter's supplying less than 1 percent of the infrastructure's value in hardware or commonplace electronic components can hardly be termed meaningful. On the other hand, in the case of a broad multilateral organization comprising many countries, large and small, with shares ranging from a fraction of 1 percent to several 10s of percent, a participation similar in level and kind to what has just been described might well be meaningful to the participating country.

Another factor to be taken into account when considering joint ventures in advanced technological developments is, obviously, the relative level of industrial development of the participating countries. Countries with more or less comparable industrial backgrounds, similar technical outlook and mutually compatible management practices will find it easier to pool their resources.

This description of potential international partners will focus first and foremost on those industrialized countries which at present are displaying a certain amount of interest, or at any rate curiosity, toward "space stations." This list includes Europe–as a whole through the European Space Agency and as exemplified by countries like France, the Federal Republic of Germany and Italy–and Japan and Canada.

Among the industrialized countries, the Soviet Union also deserves some mention, though hardly as a likely participant in a U.S.-sponsored program. Rather, as a major space power already engaged in its own program of developing, emplacing, and using in-space infrastructure, the Soviet Union is a potential competitor to the United States in offering opportunities for international involvement in such activity.

Among the developing countries, some have acquired enough space technology capability to design and build indigenous satellites and launch vehicles (China, India), and others have ambitious plans to do so in the future (Brazil). These and others deserve some attention, especially as possible participants in a broad multilateral effort.

### EUROPEAN SPACE AGENCY

Although joint European endeavors in space date back to the early 1960s, the present European Space Agency (ESA) was founded in May 1975. ESA was the successor to two earlier organizations, the European Launcher Development Organization (ELDO) and the European Space Research Organization (ESRO). It is of interest to recall briefly the history of these organizations, insofar as it sheds some light on U. S.-European relationships in space endeavors as well as on how international space organizations perform.

**In 1960-1961 a number of European countries (Belgium, France, Germany, Italy, the Netherlands, and the United Kingdom) became aware of the political and scientific benefits to be drawn from space activities (awareness of potential economic benefits emerged some years later).** They understood also that a pooling of their resources and efforts was necessary to compete with the United States and the U.S.S.R. in at least certain key areas—leaving out the development of staffed capabilities in which the superpowers were competing strongly for what appeared to be essentially national prestige reasons. These countries also recognized the importance of a comprehensive program including satellite as well as launch vehicle development.

ESRO was created to deal with satellite development, and it did so successfully. From 1967 to 1975, ESRO launched (with U.S.-built rockets) nine satellites, conducted a large number of experiments in space, engaged in successful cooperative projects with NASA, and managed to have its mandate enlarged to encompass applications satellites. The organization built up a competent and well-organized executive and technical staff which ran three technical field centers and a network of tracking stations.

ELDO, meanwhile, kept running into trouble, although it had only one project to deal with, the development of Europa, a medium-size rocket, roughly equivalent to the U.S.-built Atlas-Agena. Poor management structure was the main source of trouble; ELDO had almost no authority of its own, but acted as a sort of coordinating agency for separate national projects (a British first stage, a French second stage, a German third stage, Italian payload fairings, etc.). Additional problems arose from the fact that system and subsystem development had to proceed in parallel. The first stage was virtually completely developed at the start of the program and suffered only one minor failure in nine flights. Each of the remaining stages experienced failures on its first operational flight as an element of the complete vehicle: as a result, there was a string of six failures in which, in turn, each major element became successful.

The program was further marred by a formidable escalation of costs, and, when its eleventh test flight ended in failure at the end of 1971, it was finally canceled after $700 million had been spent.

At about the same time, the United States had stimulated ELDO, ESRO, and their member states to consider whether Europe should build a major segment of NASA's proposed space transportation system (STS), then referred to as the "post-Apollo program." By **1972, agreement seemed to be within reach; the task allocated to Europe was development of a "space tug," an advanced rocket-stage** to be used to transfer payloads from the Shuttle's low orbit to higher ones, including the commercially essential geostationary orbit, The tug appeared to be a good candidate for cooperation, insofar as it was indeed an important segment of the STS—almost a key one—and because in developing it, Europe could draw from its unhappy but extensive experience in rocketry. Furthermore, it would enable Europeans to keep working and making progress in what they felt was an essential area–i.e., launch vehicle development.

In mid-1 972, however, the United States decided to withdraw the space tug proposal, "partly because the entire post-Apollo program was being scaled back, because of doubts about European technical capabilities, and also because the Air Force thought the military potential of the tug was too great to permit dependence on outside sources."[18-19]

Also, during the same period, France and the Federal Republic of Germany (FRG) were negotiating with the United States for the launching of their jointly built Symphonic telecommunications satellite, which the cancellation of the Europa project left without a launch vehicle. The United States agreed initially to launch Symphonic, but required that the satellite be declared experimental rather than operational. The United States thus complied with its policy of assisting with launchings provided they were for peaceful purposes and in compliance with "relevant international arrangements." This was a reference to the INTELSAT Agreement which required signatories to avoid "significant economic harm" to the organization caused by regional competition, To France especially, and perhaps to a lesser degree to the FRG, these conditions were construed as an attempt by the United States (and other INTELSAT partners who shared in this position) to keep them out of the expanding satellite telecommunications business.

These events acted as catalysts in the setting up (in 1973) of the principles which were to govern the future ESA as well as in the drafting of its program. Based on unsatisfactory European experience in obtaining U.S. launch assurances, the French found excellent grounds for advocating development of an autonomous European launch capability, and succeeded in obtaining from its partners a 40-percent participation in the previously French-only program to develop the Ariane launcher. The FRG, though disappointed by the withdrawal of the tug proposal, nevertheless sought out European participation in the U.S. space transportation system through development of a "sortie laboratory," later named Spacelab.

The United Kingdom agreed to go along with a "package deal" which was worked out in July 1973, whereby France funded 60 percent of Ariane, the FRG about the same percentage of Spacelab, and the U.K. 56 percent of a European maritime communications satellite, later called MARECS. Each of the three countries also agreed to take a minor share of the two others' favorite projects. With this "package deal" accepted, the creation of ESA could proceed, and the agency began operation in May 1975. The stated objectives of the ESA include:

[18] *Civilian Space Policy and Applications* (Washington, DC: U.S. Congress, Office of Technology Assessment OTA-STI-1 77, 1982), p. 363.
[19] A more detailed discussion of European involvement in NASA'S post-Apollo efforts is provided below.

— developing and implementing a long-term space policy;
— carrying out space activities;
— coordinating the European space program and the space programs of its member states; and
— developing and implementing an industrial policy appropriate for its programs.

The agency, in addition to carrying out major but optional projects such as Ariane and Spacelab, carries out a space science program planned on a 5-year basis. This science program and ESA's operating budget call for mandatory financial contributions from its member states. Table C-1 lists the current distribution of such contributions for the ESA science program. In constant-dollar terms, the ESA budget for mandatory programs has remained virtually constant since the organization's inception.

ESA runs a comprehensive set of space programs.

1. **Communications Satellites-a** broad and vigorous program, with several satellites in orbit (OTS, an experimental spacecraft, and MARECS, leased to INMARSAT to provide operational maritime communications); with more to be launched (ECS-1 and -2, for the purpose of setting up a regional satcom system); and with a large communications satellite (L-SAT) under development. The first L-SAT payload includes four different experiments, one of which is to test direct-to-the-home TV broadcasting.
2. **Remote Sensing–as** a contribution to a global program set up under the auspices of the World Meteorological Organization, ESA launched two METEOSAT geostationary weather satellites similar to the U.S. GMS. The second of these satellites was carried in orbit by ESA's own launcher (Ariane), and ESA's member states have agreed to keep the METEOSAT system in operational condition for at least 10 years (by replacing the satellites when they fail in orbit). The Agency also has under development an advanced coastal and oceanic monitoring satellite (ERS-1) equipped with a radar and other microwave instruments. Other remote-sensing activities are also underway (data reception and dissemination, Spacelab-borne high-resolution camera).
3. Space Sciences-ESA has pursued ESRO's tradition of ambitious scientific satellite projects. Four of these are presently operating successfully while several more are in the development phase. Most notable is GIOITO, a spacecraft to fly by Halley's Comet in 1986. Science also is an area where cooperation with NASA has been and is extensive; ESA is contributing several major subsystems on the Space Telescope. The two agencies also had a joint program called the International Solar Power Mission (ISPM). This was a rather sophisticated plan to send two spacecraft (one U.S.-built and the other European-built) over the two poles of the Sun. In 1981, because of budget cutbacks, NASA chose to withdraw its spacecraft from this enterprise, creating frustrations and resentment not only within the scientific community but also within political circles in Europe. The ISPM has gone ahead but now includes only a European spacecraft launched by NASA. The impact of this withdrawal is discussed later in this appendix.
4. **Launch Vehicles–this** is an area where the dual nature of ESA's policy is best shown. On one hand, the Agency actively pursues its Ariane autonomous launcher program, aimed in part at competing commercially with U.S. launch vehicles; on the other hand, it is locked in, through the Spacelab program, to the use of the U.S. Shuttle. Concerning Ariane, in spite of two setbacks (failure of one development flight out of four and of the first operational flight attempted late in 1982), there were (as of July 1984) 7 successful launches out of 9 attempts, and it is definitely a technical success. The more powerful Ariane 2, 3, and 4 versions have already been approved and funded by ESA. Commercial success also is expected during the next several years as a result of several external factors: delays in the Shuttle development schedule, high cost of U.S. expendable vehicles such as Delta or Atlas-Centaur (resulting, in turn, from low production volume), and an insufficient number of Shuttle flights. A private corporation (Arianespace) has been established to finance and market Ariane through active salesmanship and promotion.

**Table C-1.—ESA Science Budget**

| Member States | Percent contribution to ESA's science program |
|---|---|
| Belgium | 4.49 |
| Denmark | 2.51 |
| France | 21.40 |
| Federal Republic of Germany | 25.57 |
| Ireland | 0.54 |
| Italy | 12.46 |
| Netherlands | 6.00 |
| Spain | 5.04 |
| Sweden | 4.25 |
| Switzerland | 3.99 |
| United Kingdom | 13.75 |

Spacelab was successfully launched aboard the Shuttle in November 1983. Slippages in the launch schedule, cost overruns, and technical interface problems—which each party tended to attribute to the other—have at times caused a certain amount of strain between NASA and ESA, but probably nothing more than is to be expected in such an ambitious cooperative effort.[20] The question remains, however, of the scope which will be given to Spacelab's utilization, and of who is willing to pay for the exploitation of its capabilities. How this question is resolved will have an influence on European attitudes toward participation in a U.S. "space station" program.

5. **Future Plans**–These are still in the process of being drawn up, but it is worthwhile to point out that ESA has allocated funds not only to evaluate those options which are natural follow-ons of present programs (like an advanced heavy version of Ariane beyond the planned version 4) but also to study explicitly the prospects of "transatlantic" cooperation. Within the next 2 years, ESA must decide which of the major options identified by its long-term space transportation plan to follow: cooperation with the United States in developing space infrastructure, and/or pursuing European-only development of modern capabilities for space operations. The timing of U.S. and ESA decisions on future programs is now compatible, but will not remain so indefinitely.

ESA also has an active program of basic research in materials processing, one of the most promising candidates for widescale applications aboard a "space station." This research program is carried out at present on a variety of vehicles, among which Spacelab is prominent. ESA's Council has already approved and funded the development of another in-space infrastructure element for this purpose; a space "platform," it is named EURECA (European Retrievable Carrier).

EURECA is designed to carry experiments that require longer times on orbit than are available on the Shuttle. It will include materials processing facilities (furnaces and the like), and will be launched and retrieved by the Shuttle. Its design will provide enough maneuvering and power supply capability to sustain a prolonged (i.e., 6 months) orbital life of its own. These features give to EURECA all the appearances of a "free-flyer" which could be tended by other, future infrastructure elements and actually make it look like a first step toward ESA participation in a "space station."

All of the above points clearly toward an ESA willingness to consider seriously the possibility of a European participation in a space infrastructure program. Past history, however, also points strongly toward a European tendency to balance its commitments carefully between the acquisition of autonomous capabilities (as exemplified by Ariane) and the involvement with U.S. projects (e.g., Spacelab).

To sum up, it appears that, notwithstanding its policy of retaining capabilities of its own, especially in those areas where commercial competition may take place, ESA is a likely candidate for a substantial cooperative effort with NASA because:

a. ESA and its individual member-states have a longstanding tradition of cooperation with NASA.
b. Although much smaller, total European space expenditures are commensurate with NASA's (about one fourth). Given that the consolidated gross national product (GNP) of ESA's member-states is somewhat larger than the GNP of the United States, there seems to be room for a substantial increase in these expenditures. However, present trends do not seem to point in that direction.
c. The ESA Executive (headquarters and technical centers) is driven by internal motivations which are somewhat similar to NASA's, and ESA is striving to define and get authorization for an ambitious long-range program which would give size, focus and purpose to its activity.
d. Most member-states of ESA are at least willing to take a look at a possible U.S. offer to cooperate on a "space station," and generally believe that the very scope of such a program makes it necessary to approach it jointly in order to achieve a meaningful level of participation.

In spite of what has just been said, some major member-states of the European Space Agency do not want at the present juncture to preclude bilateral cooperation with the United States (if they deem it worthwhile and no satisfactory joint European arrangement with the United States can be devised.) These countries appear at present to be France, the FRG, and Italy, which together account for over so percent of ESA's resources. In any case, even though these countries would be likely to end up participating in a U.S. space infrastructure program through ESA if such a program is instituted, they will assess their interests and decide upon their course irrespective of the joint European assessment, and it is therefore worthwhile to take a closer look at each one.

## FRANCE

France has always aimed at being the "third space power" after the United States and the Soviet Union, and has indeed managed to build up the largest and

[20] Many modifications had to be made to Spacelab as a result of changes in the Shuttle interface. This situation was somewhat reminiscent of the operations of ELDO, for it arose, and inevitably so, from the parallel development of a system and one of its major subsystems.

**most** comprehensive space program in Europe and the third-largest in the world. Budgetary appropriations are an indication of this; in 1983 (approximate figures) France's space expenses will be ***$545*** million (as compared with the FRG's $325 million, or Japan's $450 million). French ambitions date back to the de Gaulle era, and it was as early as 1966 that France orbited its first satellite with a French-built rocket, a few days before its second satellite was launched by NASA. Since then, the French program has substantially shifted its emphasis away from national prestige towards economic competitiveness, especially for export purposes.

Therefore, while maintaining a fair-sized space science program, CNES (the French space agency) has been active mostly in launch vehicle development (Ariane, under ESA's supervision), communication satellites construction (participation in joint European programs; national TELECOM 1 satellites to be launched in 1984; a bilateral program with the FRG to launch direct TV broadcasting satellites in 1985), land remote-sensing systems (the first satellite of which, named SPOT 1, is to be launched in 1986 and will incorporate two high-resolution instruments and stereoscopic imaging capability), and a variety of other programs.

French industry, meanwhile, does not content itself with implementing national programs and its share of European ones, but also strives very hard to compete for space-related export sales. Ariane launch services have been sold to several organizations or countries–including private firms in the United States—and communications satellites to ARABSAT (a consortium of Arab countries).

CNES also runs a research program to evaluate materials processing applications, and has laid out plans and preliminary designs for a specialized automated "manufacturing-in-space system" named SOLARIS. This concept features a platform (without crew facilities) equipped with furnaces, adequate power supply, and other ancillary subsystems including a robot manipulator arm; a transfer and raw material supply stage to be launched by Ariane 4; and a ballistic reentry capsule to bring processed items back to Earth. An effort to promote interest in this concept among other ESA member-states has not met with success up to now, perhaps because it was felt to be premature.

In sum, France's space policy places a strong emphasis on "autonomy" (on a European level at least, if not in the strictly national sense). This is due in part to a frame of mind inherited from the de Gaulle era, but now even more so to economic considerations; commercial competition requires that a country be able to play its own hand independently. Furthermore, **France and the FRG are now discussing plans for a military reconnaissance satellite: this makes autonomy all the more important to French decision makers.**

Hence the staunch support (and high financial contribution) given to the Ariane program, and the carefully balanced bilateral cooperation with many different countries: the United States, the FRG, Sweden, and the U.S.S.R. particularly. In ESA's policymaking bodies, France has been and will probably remain in the future one of the staunchest advocates of the dual approach of balancing cooperation with the United States with an equally strong commitment to autonomous capabilities.

### THE FEDERAL REPUBLIC OF GERMANY

Just like France and other members of ESA, the FRG conducts the largest share of its space efforts through that agency's joint programs. In particular, the FRG government strongly supported the Spacelab program at its inception in the early 1970s, and since then has provided more than 50 percent of its funding. The FRG also provides the largest single contribution to ESA's remote-sensing programs (METEOSAT, ERS), and land communications programs (OTS, ETS). More recently, when trying to shape ESA's future programs, the FRG has acted as a promoter of the EURECA project described earlier, while France was promoting Ariane **4.**

**The** FRG, however, is also engaged in a number of bilateral cooperative undertakings. Along with France, the FRG is developing TV-SAT, a direct television broadcasting satellite: experience thus gained will enable its electronics and aerospace firms to compete for export sales in what is expected to become one of the fastest growing markets, that of DBS (direct broadcasting satellites). Another important area of bilateral endeavor is space science, not only with the United States (several FRG scientific satellites have been launched by the United States), but also with France, Sweden, and the United Kingdom.

Strong emphasis on materials science and processing is a characteristic feature of the FRG's space program. This includes suborbital flights on sounding rockets, which provide a few minutes of "near zero gravity"; small payload packages to be carried by the Shuttle (referred to by NASA as "Getaway Specials") and of course utilization of Spacelab. The FRG has conducted major experiments on the first Spacelab mission in 1983 (which was a joint U.S.-European flight). **It** has also purchased and will manage a wholly FRG Spacelab mission called D-1, to be flown in October **1985.**

The FRG materials processing program is not purely scientific in orientation. It aims at involving the industrial sector early in exploring potential applications of space-processed metals, composite metals, crystals, and chemicals. This close association of government support with industry's initiative seems to work well, all the more so because the FRG's major aerospace and electronics firms play a much larger role in initiating and funding research and development efforts than do their counterparts in other European countries.

Generally speaking, this fits in well with what appears to be the overall goal of the FRG's space policy: to encourage its national aerospace industry, to promote scientific and industrial/technological research, and to rely on ESA'S programs to stay in the applications business. The keyword seems to be "competition through technological capability" rather than "competition through nationally proven systems." (This latter could well be the French motto.)

All this supports the views expressed in many quarters that among ESA's member-states the FRG is the most "transatlantic-rein ded," and that its attitude towards cooperative ventures with the United States is likely to be more positive than that of the French. There is no doubt that in ESA's councils, and even more freely so when drafting its national program, the FRG would consider very seriously a possible invitation from the United States to participate in "space station" development. Also, the FRG has been less outspoken than France in its reactions to the frustrations which have resulted from some of the past U. S.-Europe joint ventures. But the frustrations were there all the same, and like most of its European partners, the FRG will weigh closely the pros and cons of the possible modes of cooperation.

## ITALY

With a 1983 budget for space activities in the range of$150 million, of which slightly more than one-half makes up its contribution to ESA programs, Italy is clearly demonstrating a willingness to implement a space policy of its own. The framing of such a policy seems to be hindered by lack of central coordination among the several interested government agencies: Defense, Communications, and the National Research Council (CNR). The last, however, seems to be in the process of taking the lead.

In 1979, CNR managed to secure government approval for an overall plan calling for a sharp increase in funding; this has been partly implemented. Most of the increase is to fund national programs, especially in the field of communications satellites: a system named ITALSAT is being considered, as well as a direct broadcasting TV system. Meanwhile, Italy has strongly supported ESA's experimental L-SAT program and has taken a leading position in advanced communications technology (20-30 gigahertz) through the SIRIO-2 meteorological data dissemination satellite, which was destroyed in 1982 when the first Ariane operational flight failed to achieve orbit.

Besides its marked interest in communications-related space activities, Italy has undertaken several bilateral cooperative ventures with NASA, particularly in areas not covered by European programs. In the past, these have included an imaginative concept called San Marco, involving several launchings of small scientific satellites by U.S.-made SCOUT rockets from an off-shore platform located on the equator off the coast of Kenya. More recently, Italy started developing IRIS, a small booster stage for Shuttle payloads. Remote sensing is another theme for U.S.-Italian cooperation, if only because Italy runs the main European Landsat data receiving station located at Fucino near Rome.

The latest scheme considered for a joint U.S.-Italian venture is worth mentioning because of its obvious relation to in-space activities. It is the so called "tethered satellite" concept, in which a scientific satellite is to be attached by a long umbilical cord to the Shuttle or another infrastructure element in orbit. Italy now has a Memorandum of Understanding with NASA regarding this matter, and joint studies are under way to develop the concept, Perhaps because of this, Italy up to now has been one of the most eager of ESA's member-states to participate in informal discussions on U.S.-European cooperation in a "space station" development program.

## THE UNITED KINGDOM

Although the United Kingdom initially showed little inclination to share in NASA's "space station" aspirations, this situation has changed over the past year, with U.K. interest coming to focus on platforms. Great Britain is, after France and the FRG, the third largest contributor to ESA's budget, but the lion's share of its attention over the past several years has been given to satellite communications, within ESA as well as nationally. As it happens, a "space station" has been thought, until recently, to be of relatively little value to satellite communications (except in the very long term). Britain's developing interest in long-term in-orbit infrastructure, coupled with its intention of maintaining its vigorous space science program (pursued both through ESA and bilaterally with NASA) and its rapidly growing interest in remote sensing, may signal a move toward a more comprehensive and diversified space program.

## OTHER ESA MEMBER-STATES

This paper has dwelt at some length on those members of ESA which deem it preferable to participate directly, as well as through ESA, in talks with NASA on "space station" matters, This does by no means imply a lack of interest on other member countries' parts. However, it does make it more difficult to assess their positions with respect to possible U.S. overtures since those positions are not debated publicly.[21] One fact remains, however: all ESA's members have entrusted to the Agency a long-term program planning mandate, and have provided funds therefore. And this mandate explicitly encompasses consideration of "transatlantic" cooperation on a space station.

### CANADA

There is a General Agreement on Cooperation between Canada and ESA, which makes Canadian participation in an ESA contribution to a space infrastructure program at least a possibility. Its longstanding tradition of bilateral cooperation with the United States, however, prompts Canada, through its National Research Council, to evaluate its interest in a "space station" independently.

Canada's expenditures in space in 1983 were about $100 million. Apart from a pioneering effort to operate domestic satellite communications systems (the ANIK spacecraft family built by Hughes) and a number of joint scientific projects with the United States, Canada's major bilateral program with NASA is the development of the remote manipulator arm for the Shuttle. In return for a NASA commitment to purchase additional arms from Toronto-based Spar Aerospace Ltd., Canada has funded the $100 million development of the first flight unit, which has been successfully tested on Shuttle flights. Manipulator systems could be important features of space infrastructure and thus are candidates for Canadian contribution.

### JAPAN

With the exception of bilateral cooperation with the United States, Japan has, to date, carried the burden of its space activities alone.[22] Fairly constant in the last few years, Japan's space expenditures per annum amount to approximately $45O million, a budget nearly one half the size of the European Space Agency's.

Space development in Japan is executed under the leadership of the Space Activities Commission (SAC), an advisory organ to the Prime Minister. The main executive agency is the National Space Development Agency (NASDA), established in 1969 to undertake the development of applications satellites and related launch vehicles, and to conduct launching and tracking operations. Another agency, the Institute of Space and Astronautical Science (ISAS), is in charge of scientific space programs carried out on balloons, sounding rockets, and satellites. ISAS builds its own family of launch vehicles and runs its own launch center at Kagoshima, independently of NASDA's launch facilities which are located at Tanegashima.

Japan is the only country where large-scale space science and space applications programs are carried out by two completely separate entities, reporting to different departments of government; while ISAS is an "independent national institute" under the Ministry of Education, NASDA reports to the Prime Minister's Office through the Science and Technology Agency. But NASDA also carries out programs on behalf of, and draws funds from, other ministries: Transport (meteorology), Posts and Telecommunications,

From 1970 to 1981, Japan successfully launched 21 satellites, developed two families of launch vehicles, undertook the development of several more satellites and of a third type of launcher, and readied a number of experiments to be carried by the Shuttle and Spacelab. For the time being, this effort has been directed exclusively towards meeting domestic needs (communications, remote sensing) and the acquisition of technology and expertise through a wide range of scientific and experimental programs. Consequently, there has been, to date, little effort by Japan to compete with other space powers in offering commercial services abroad. (An exception is the sale of ground stations for setting up communications networks or remote-sensing data reception; in these areas, Japanese industry has captured a good share of the world market.)

Until very recently, Japan has cooperated closely with NASA as well as with U.S. industry. In the field of space science, there have been a number of scientific exchanges, and this will continue as Japan plans to use flight opportunities on the Shuttle and Spacelab. Many of Japan's applications satellites, whether experimental or operational, have been developed within the framework of joint ventures among Japanese and U.S. companies. As far as launch vehicles are concerned, the "Mu" series of small launchers has been an indigenous development from the start, but the larger "N" family to be used to launch applications satellites has relied on technology transfers from the United States.

[21] The position of the smaller states in ESA is somewhat similar to that of those in the European Economic Community. At the Economic Summit, the big four European nations attend in their own right; the remaining six are represented by the President of the Commission.

[22] Japan may now be expanding its sphere of space cooperation. It has recently opened a liaison office in Paris, for example.

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The first stage of the "N1" version is in effect a Thor-Delta first stage built under license, and the third stage is a U.S. (Thiokol) production. The improved "N2" version goes even further in this direction, as it also includes a U.S. (Aerojet) second stage. All told, Japanese industry builds barely more than half of the "N2" vehicle. It should be pointed out that the U. S.-Japanese Agreement on Space Activities (signed in 1969) imposes restrictions on the use of these U.S. technologies and hardware by curbing transfer to third parties. The new launcher design, named Hi-A (roughly equivalent to ESA's Ariane 1 ) will alter this situation significantly, for the second stage (which will burn advanced liquid hydrogen/oxygen propellants) and the third stage, as well as the guidance system, will be of indigenous design and manufacture. When the H1 -A becomes operational, Japan will be only one step removed from an autonomous launch capability, namely the development of a new first stage (for which preliminary designs have already been proposed).

In addition to the obvious desire to increase Japanese industry's share of the construction of space hardware, this trend towards autonomy could be based on two grounds. First, there may be dissatisfaction with U.S.-supplied hardware; indeed, in 1979 and 1980 two costly launch failures were traced to probable malfunction of U.S.-supplied subsystems, and in the aftermath of these events it was decided to accelerate indigenous development.[23] Second, an autonomous launch capability clearly would enable Japan to offer full-scale commercial services in space applacations.[24]

Another aspect of Japan's space policy is that little has been done to diversify its sources for technology procurement and partnerships beyond the United States. Regular consultations are held, for instance, with ESA, but amount to little beyond some coordination or satellite tracking stations. France was approached in the early 1970s and at several points later on for possible cooperation on liquid hydrogen-fueled rocket engines, but to no avail; the parties did not reach even a conceptual definition of a cooperative venture.

**In May 1984, Japan announced a plan** for its participation in the U.S. "space station" program. The plan calls for Japan's development of an experimental module to carry out life science and materials science experiments, to be performed by one Japanese worker. The module will be connected with the U.S. infrastructure. It will include a manipulator arm, experimental devices for studies related to pharmaceuticals, crystals, compound materials, and a self-sufficiency food system. The development expenses to be paid by Japan are estimated to be 200-300 billion yen [$0.9-1.4 billion (1984)].

## DEVELOPING COUNTRIES

Some developing countries can operate in space on their own, as is exemplified by India and the People's Republic of China. Both countries have launched several satellites using indigenous launchers. Both countries are engaged in efforts to use existing systems to acquire expertise in important applications areas like meteorology, remote sensing, communications, and educational broadcasting. Details of programs and technology are not always very well known outside of these countries; most Western observers who have visited space facilities in India and China have been impressed by their potential, if not always by their present condition. **In both countries, an adequate substratum** of **advanced industries is missing—especially** in the areas of electronic components, high-grade materials, and chemicals—and strains are caused by conflicting priorities and by lack of foreign exchange. Shortages of trained technicians add further difficulties, but the foundation has been laid for further activities in space.

Other developing countries are striving to reach the stage already attained by China and India. A few years ago, it seemed that Brazil was on the verge of getting a comprehensive program started, including its own satellites and launchers, developed in part indigenously and in part with foreign help. (France and the FRG had actually almost concluded agreements with Brazil to that effect.) Political developments, growing economic difficulties, and diplomatic pressures from some countries that were, perhaps, wary of Brazil's access to missile technology have lowered these prospects considerably. Although Brazil has not managed to become a builder of space systems, it is an active user of existing systems (INTELSAT for communications, LANDSAT for remote sensing), and still plans to operate a satellite communications system of its own, which would be procured abroad.

Utilization of space technology, in contrast to its development, is almost worldwide. In particular, more than 100 participating countries are members in

[23] The Japanese reaction to the recent failure of transponders on their direct broadcast satellite suggests that the drive toward self-sufficiency will probably be further intensified.

[24] It has been pointed out that Japan's launch capabilities are severely limited by agreements with the fishing industry, whereby the Tanegashima launch center can be used only four months per year. But this restriction clearly would not be sufficient to deter Japan from its traditional policy of entering the world market after a technology has been mastered and tried out on domestic markets.

**INTELSAT, and each of them operates at least one ground station.** In addition, there are more than half a dozen LANDSAT and/or SPOT remote-sensing data reception stations in existence or under construction throughout the so-called Third World.[25]

Are there potential partners in a joint "space station" venture to be found among these countries, especially among those which have some sort of aerospace industry of their own? There is no basic reason why the answer should be no, but it must be pointed out that:

- to some of these countries, cooperation with the United States would pose a tricky, if not insurmountable, political challenge, unless the mode of cooperation approached a "genuinely international" one;
- financial participation of these countries could probably not exceed a very small percentage of the total cost; and
- such a program exceeds by far the ambitions that these countries set at present for their endeavors in space, and going along with it in an international context would not satisfy the fundamental craving for autonomy and self-assertion which often, to some extent, underlies their space policies.

Concerning the second point, it might be argued that a large number of small percentages can amount to a sizable sum. To give one example: 82 out of 102 signatures of INTELSAT own each less than 1 percent of the shares, but their combined participation amounts to more than 20 percent. As to the third point, a genuinely international structure could be acceptable to countries who see space activities as a means of self-assertion; for, even if the system were built and operated by industrialized countries, it would at least be jointly owned/managed by all. These considerations all point to the same conclusions: a significant level of participation by developing countries is unlikely to occur, except possibly within some broad international framework and unless aggressively pursued by the United States.

## THE SOVIET UNION

**Under present and foreseeable political circumstances, the Soviet Union would be unlikely to participate in** in a space venture initiated and led by the United States. Even the prospects of its participating in a genuinely international system seem very remote. One need only remember that the Soviet Union, and the other Eastern-bloc countries, have never joined the INTELSAT organization. These countries decided instead to create their own international satellite communications system, named INTERSPUTNIK; since the two systems have to be linked somehow, there are INTELSAT ground stations in the U. S. S. R., Cuba, and Romania, but these countries are users of and not parties to INTELSAT. **It** is true that the Soviet Union is party to several international satellite systems, notably INMARSAT (which is, roughly speaking, to maritime communications, what INTELSAT is to ground communications) and SARSAT-CORPAS (an experimental satellite assisted search and rescue system). But these were created in a context where the United States did not play a dominant role.

However, it is not possible to discuss international prospects for international involvement in a "space station" without mentioning the Soviet Union, for that country does operate its own in-space infrastructure: Salyut-Soyuz-Progress.[26] Furthermore, the Soviet Union has provided opportunities to several other countries to have one or more of their citizens visit this infrastructure.

The Soviets have never concealed their ultimate intention to have some of their people in space operating permanent facilities there, and Salyut is clearly a major step towards that goal. The pace of its future evolution is, however, open to conjecture. The Salyut-Soyuz-Progress infrastructure, as developed to date, does not exhibit all the features to which NASA aspires for U.S. in-space infrastructure.

For instance, the Salyut's crew can perform work only inside the station, or, when spacewalking, only very close to it, by remaining tethered. The Soviets apparently have no such thing as manned maneuvering units, teleoperated maneuvering systems, and the like. As a result, the crew cannot tend other spacecraft which might co-orbit or rendezvous with their complex, in order to maintain, service, or repair them. This reflects adversely on all material processing research: Salyut, because of perturbations caused by

[25] Each of these stations usually serves several countries.

[26] The name SALYUT designates a series of manned orbital laboratories, launched and operated one at a time since 1971. The system presently active, SALYUT 7, is likely to stay several years in orbit, as did its predecessor SALYUT 6, both because of design improvements and because a fair amount of in-orbit maintenance can now be carried out by visiting crews. The spacecraft, weighing about 40,000 lbs, is launched unmanned, and later on rendezvous with SOYUZ capsules carrying a crew of 2 or 3. SALYUT 6 and 7 have also been visited by larger (30,000 lbs) unmanned craft. The usual pattern of activity is to send abroad first a "semi-permanent" crew of two for a duration now exceeding 6 months. While this crew stays on board, visiting crews of three join them (usually for a week). These visits alternate with unmanned resupply trips by PROGRESS. To date, the station has been left unoccupied for some time after the semipermanent crew has accomplished its long-duration stay, after which the cycle starts again. For a more complete discussion, see the OTA Technical Memorandum *Salyut: Soviet Steps Toward Permanent Human Presence in Space*, December 1982.

crew members' movements and the lack of a free-flying platform in its vicinity, does not provide the very low level of residual "gravity" necessary for the implementation of finely tuned experiments.

In spite of this, and other present limitations, the Salyut has been used extensively for military and civilian activities. In the latter case, where some results are known, cosmonauts have performed useful work in life sciences, Earth observation, astronomy, materials processing, and technology development. Furthermore, Salyut has enabled the Soviet Union to gain the prestige associated with having some of its people in orbit.

Cooperation with the Soviet Union in space is a complex matter.[27] Planning is difficult when future plans are, by definition, to be kept secret. Communication with authoritative Soviet representatives tends to be scant, slow, and often "beside the point." Standards, methods and even terminology are very different from those in use outside the Soviet Union. Consequently, project managers and teams from these countries who have been involved in bilateral programs with the U.S.S.R. have usually experienced great difficulties in keeping cost and schedule under control. However, Soviet teams have proven their ability to be flexible and imaginative when they feel the need for it. For example, West German scientists whose instruments are to be flown on the upcoming Soviet VEGA mission to Halley's Comet have found the cooperative arrangements quite satisfactory.

Whatever the difficulties inherent in international cooperation with the U.S.S.R. in space activities, there are countries which have no other choice, and there are countries which find advantage in balancing cooperation with the United States with joint ventures with the Soviet Union. It seems unlikely, however, that these latter countries would go so far as to bypass cooperation with the United States on a "space station" by exclusive recourse to analogous Soviet flight opportunities.

## Factors Influencing Assessment of International Involvement in U.S. "Space Station" Program

### PAST EXPERIENCE

Both the United States and its potential partners will have a substantial historical record in mind when it comes time to decide whether, and how, to proceed in a cooperative "space station" endeavor.

The debate over European participation in NASA's post-Apollo program is by far the most important past experience, since it was the only time that the United States invited its major allies–Europe, Canada, Australia, and Japan—to participate in an effort which was at the core of NASA's plans for the future. While there had been significant scientific cooperation prior to 1969, particularly with Europe, there was a deliberate decision as NASA's post-Apollo efforts were being planned in 1969 and 1970 to make international involvement in those efforts, particularly of U.S. allies, a major theme.

Armed with what he thought was a mandate from President Richard Nixon to seek such involvement, NASA Administrator Thomas Paine toured Europe and the Far East inviting other countries to consider substantial involvement in the emerging U.S. post-Apollo plans, which at the time included a "space station," Shuttle, reusable orbital transfer vehicle ("space tug"), and, ultimately, having people visit Mars. European nations, through ELDO and ESRO, were particularly responsive to Paine's initiative, and began to study in some detail various forms of participation; neither Japan nor Australia made an active response to the U.S. initiative.

A primary NASA objective in initiating the post-Apollo dialogue was "to stimulate Europeans to rethink their present limited space objectives, to help them avoid wasting resources on obsolescent developments, and eventually to establish more considerable prospects for future international collaboration on major space projects."[28] In particular, NASA was eager to steer Europe away from developing an autonomous launch capability. Plans for an expendable European launcher were the "obsolescent developments" to which Paine was referring.

At the time NASA was offering to involve other countries in an ambitious post-Apollo enterprise; it did not have White House or congressional approval for the programs it was promoting overseas. Indeed, one tactic NASA may have been using to gain program approval at home was to point out the problems involved in withdrawing from incipient agreements with Europe to cooperate in those programs. Potential U.S. partners were aware of the NASA approach; in September 1970, for example, "American space officials were asked for assurance that, if West European nations scrapped their space programs in favor of a joint effort with the United States, the latter would not, in an economy move, back down."[29]

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[27] U.S./U.S.S.R. cooperation in space will be examined by OTA in detail in a technical memorandum to be published late in 1984.

[28] Letter from Thomas Paine, NASA Administrator, to the President, Nov. 7, 1969.

[29] *New York Times,* Sept. 24, 1970, P. 64.

By 1971, **only the Shuttle and orbital transfer** vehicle remained as part of NASA's post-Apollo plans; the "space station" had been shelved for the indefinite future. NASA **was suggesting to Europe that its participation involve developing some portion of the airframe of the Shuttle orbiter and total responsibility** for developing the space tug. However, others within the Executive Branch were skeptical that Europe had the technical capability to develop the tug on its own, and were concerned that the United States might, in the **process of assisting Europe** in the tug development, transfer sensitive and/or economically valuable U.S. technology.

Throughout 1970 and 1971, negotiations on European involvement in post-Apollo development efforts were linked to a European request for U.S. assurance that it would launch European communication satellites. The United States had for some time resisted providing such assurances on terms acceptable to Europe because of its own economic interests, both INTELSAT and in U.S. industry's domination of the market for communications satellites, but in September 1971 a compromise on the issue acceptable to both sides was reached and this obstacle to the post-Apollo negotiations was removed.

President Nixon approved development of the Shuttle on January 5, 1972. Shortly afterwards, a joint NASA/European "experts group" met and reported that "NASA . . . continued to encourage European participation in development and use of the post-Apollo program. . . . NASA's expectation [was] that European participation in development of the Shuttle would be within the context of a broader program which included multilateral European responsibility for development of a major element such as reusable space tugs . . , or Shuttle-borne orbital laboratories . . , ."[30]

The suggestion that there was an alternative to European development of the space tug had emerged within the United States during 1971; the so-called "sortie can" laboratory (also called a research and applications module) was seen as clearly within European capabilities, offering no risks of unwanted technology transfer, having no military implications, and providing clean technical and managerial interfaces with development of the Shuttle orbiter itself. On the other hand, two factors militated against Europe's developing the tug: 1 ) recognition that the Shuttle and its associated orbital transfer vehicle would be used by the United States for military, as well as civilian, purposes, and 2) NASA's concern over housing the tug, with its planned cryogenic fuel, in the Shuttle payload bay.

In June 1972, the United States withdrew (without warning) the option of Europe's participation being development of the tug, and told Europe that the only choice left for substantial participation was development of the sortie laboratory. Europe was also excluded from direct involvement in developing any element of the Shuttle orbiter itself. This decision came as a blow to Europe, which had already spent substantial sums both on tug development and, particularly in the United Kingdom and Italy, on orbiter design work in collaboration with U.S. industry. **In terms of stimulus to European technical and industrial capability and eventual sales potential, Europe viewed the sortie laboratory as a distinctly less desirable option.**

**Nevertheless, Europe (and** in particular the FRG) found the opportunity to become involved with the U.S. mainstream program for the 1970s attractive enough that it continued negotiations in a situation where the United States was clearly playing a dominant role. After a further year of negotiations, in mid-1973 Europe agreed to proceed with development of the sortie laboratory (by now named Spacelab) as part of a "package deal" which also included development of a French launcher (which became the Ariane project) and of an experimental maritime communications satellite and which called for the creation of a single European Space Agency to carry out these projects. It was the difference in cost between the expensive tug development program and the less expensive (at the time) Spacelab program which freed up the funding needed to initiate joint European support of Ariane.

The Memorandum of Understanding which governed NASA/European cooperation on Spacelab was signed in September 1973.[31] At the time of the U. S.-European agreement on Spacelab development, it was anticipated that the facility would be used extensively in conjunction with the Shuttle and that the United States would buy several Spacelabs beyond the one engineering model and one flight model which Europe agreed to develop and build at its own cost and then to deliver to NASA. This has not yet happened.

[30] NASA Press Release, Feb. 11, 1972.

[31] The MOU between NASA and ESA was a subordinate document which drew its authority from the Intergovernmental Agreement between the United States on the one hand and each of the individual governments of the ESRO Member States on the other. This Agreement was thus binding on the whole of the U.S. Government not just on NASA. Although ratified by the parliaments of several ESRO countries, it was not submitted to the U.S. Senate for ratification. As a consequence, its status was that of an "International Executive Agreement" and, as such, subordinate to U.S. domestic law. This point, which the ESRO states did not appreciate at the time, became important in 1979 in connection with a U.S. Air Force plan (later cancelled) to develop a system similar to Spacelab.

The costs of both Shuttle and Spacelab utilization have escalated to the point where extensive utilization of the full Spacelab capabilities is questionable, and the United States has bought only the minimum single additional Spacelab to which it was committed.

The Europeans knew that, under the circumstances, they would have to accept the status of a junior partner. Now that they have demonstrated their competence, they will look to agreements on a much more equitable basis as Europe considers cooperation with the United States in "space station" development. For example, the current head of CNES has questioned whether Spacelab has "fulfilled German expectations" (the FRG was the major European advocate of the program) and has suggested that "there is some question as to whether Spacelab . . . is really appreciated by the U.S. . . . **In any event, Europe does not really feel at** home in Spacelab, whose operation is now out of European hands."[32]

European acceptance of what some now perceive to be unfavorable terms in the Spacelab agreement stemmed in large part from lack of confidence in European capabilities and from a belief that only through cooperation with the United States could those capabilities be improved. Now, having brought both Spacelab and Ariane to success, Europe has much more confidence in its ability to chart its own future in space and it is likely to be a more demanding participant in negotiations with the United States over cooperative ventures.

European confidence in the United States as a cooperative partner was shaken in the spring of 1981 when the United States announced, without prior consultation with its European partners, that it was canceling a U.S. spacecraft which was part of a two-spacecraft International Solar Polar Mission (ISPM).[33] This withdrawal caused vigorous protests from not only European space officials but also representatives of foreign ministries.[34] There is general agreement that the ISPM affair was not handled well by the United States.[35] Although both the United States and Europe have managed to put ISPM in perspective, European officials are not beyond using U.S. remorse over the incident as a bargaining chip in U.S.-European negotiations on future collaboration. For a time, though, it seemed as if "aberrations such as the unilateral pullout by the United States" from the ISPM could "set back progress for years."[36] It is perhaps an indication of the basically favorable climate for U.S.-European collaboration in space activities that the ISPM incident and the Spacelab experience are viewed as lessons of what is to be avoided in future negotiations rather than reasons for not cooperating in the future.

## NATIONAL SECURITY INTERESTS

Military and national intelligence space activities provide the United States and its allies with major national security advantages, and all indications point towards reliance on them in the future. A major program like the "space station" is therefore bound to have national security implications. If a decision is made to develop a single set of infrastructure elements to satisfy all interests, civilian **and** military, then the prospect of international involvement in such a program raises critical questions. This is all the more true since new security implications may emerge as the program matures. If the future unveils unforeseen potentialities, international participation in the program may inhibit, perhaps even prevent. the United States from taking full advantage of them.

To an extent, major international involvement will obviously restrict U.S. freedom of choice in the future: it would be more difficult, for instance, for the United States to preserve the option of integrating all its efforts in space (military as well as civilian) and having a single Government agency responsible for them (though the U.S. Army and its Corps of Engineers may exemplify a possible approach). Such a drastic step has been debated and rejected in the past, but, in principle, it remains an option which international participation might foreclose. Conversely, any form **of** U.S. military activity would raise major problems for ESA as a partner, since the ESA charter precludes any involvement in military projects.[37]

A more likely future, however, is that any national security uses would rely on elements operationally separate from the civilian one, but built with similar or identical technology and perhaps making joint use of basic utilities. Dependence of any military segment(s) on parts and/or subsystems procured from foreign sources could ensue, This is a situation which will

32 Herbert Curien, "The Pride of France: a National Commitment, " *Spectrum,* September 1983, p. 75.

33 Indeed, European confidence had been shaken earlier when the United States cancel led its share in the AEROSAT program, In this instance, the U.S. withdrawal was total, and the program was stopped.

34 For a running account of the International Solar Polar Mission controversy, see articles in *Aviation Week and Space Technology,* Mar, 2, Mar. 30, Aug. 3, Sept. 28, and Dec. 28, 1981.

35 It is perhaps worth noting that the situation was aggravated because NASA was not permitted to consult or even warn ESA of the impending cancellation until the President's budget had been delivered to the Congress.

36 Noel Hinners, "Space Science and Humanistic Concerns," in Jerry Grey and Lawrence Levy, eds., *Global Implications of Space Activities* (American Institute of Aeronautics and Astronautics, 1982), p. 43.

37 Three of ESA's members (Sweden, Switzerland, and ireland) are neutral countries.

never please the military (which, like France, prefers "autonomy"), but which can probably be met with adequate licensing arrangements (e.g., those under which the AV-8 Harrier aircraft was produced). For instance, if the U.S. military were to envision using elements of any civilian space infrastructure under such circumstances, a foreign supplier could be required to entrust a U.S. official agency with all drawings and documents needed to transfer the manufacturing of the item under consideration to a U.S. supplier if such a course eventually proved to be necessary. An intergovernmental arrangement would specify those situations where the U.S. agency is authorized to implement the transfer to a national supplier, so as to protect the foreign firm's commercial interests in all other cases.

Such a device works best when the back-up supplier in the U.S. is pre-identified, so that a minimum amount of transfer of know-how, consistent with the preservation of the foreign source's interests, can be carried out in advance, thus shortening the inevitable lead time inherent in a manufacturing restart. Of course, there is always the possibility that the U.S. military could procure systems directly from non-U. S. suppliers; this has happened for a few military systems in the past.

Another security-related consequence of international participation could be that foreign participants would be exposed to the operating characteristics of the technology used by U.S. national security agencies. This could involve those parts or subsystems provided by foreign sources, and can be assessed only on a case-by-case basis. But the matter could extend beyond foreign-supplied hardware, since foreign participants will of necessity have access to a certain level of technological detail, especially those interfacing with what they supply. This, however, is not necessarily critical: in a similar instance, the Shuttle, although it can be used to carry on U.S. national security activities, is itself not a classified item. However, many aspects of Shuttle operations, such as access to the Orbiter itself, are carried out under strict security, and the military has developed separate control facilities for its use of the Shuttle.

Similarly, as the presumed leader in a space infrastructure program, the United States is bound to be in a dominant position regarding transfer of sensitive technology and industrial information. As was the case with Spacelab, all data and drawings pertaining to any foreign contribution would have to be made available to the United States in order to allow operation, maintenance, and repairs to be carried out. The United States, on the other hand, would have to provide only essential interface data to its partners. Such considerations, therefore, should not discourage the United States from seeking foreign participation, if it so desires.

Perhaps more important to national security considerations are the restrictions which might be imposed on certain national security uses of internationally developed infrastructure. While some, perhaps many, potential international partners might not oppose so-called "peaceful" military applications (e.g., military R&D, or activities in support areas such as communications, navigation, surveillance), some of them are unlikely to agree to the installation of any "battle station" on an element derived from a development program to which they are party. There is clearly no way to bypass such an issue: it would of necessity have to be settled beforehand, as explicitly as possible, in the agreement instituting the international program.

A last issue relating to national security considerations is that of the transfer of technology from the United States to foreign participants, or vice versa. There are generally two ways in which such technology transfers occur: "

1. In the course of an international development program, a certain amount of know-how is inevitably transferred among the parties to the project. This is more in the nature of general knowledge (management, organizational methodology and procedures) than of specific technological skills. The character of technical interaction between NASA and ESA in conjunction with Spacelab, even though it includes some technical assistance provided by NASA, is evidence of this.
2. If a foreign participant in charge of a given subsystem were to appear unable; at a late stage of the program, to produce a product conforming to required performance standards, it then would become necessary to assist the concerned party in meeting the specifications, a process which might involve the transfer of valuable and sensitive know-how. This can only be assessed on a case-by-case basis, but a number of safeguards can be built into the program at the start. These would include careful selection of subsystems entrusted to foreign participants and provision for midcourse assessment of performance. Of course, the reverse possibility now exists as well: that the United States could gain access to valuable technological know-how from other countries.

## POTENTIAL PRIVATE-SECTOR INVOLVEMENT

In principle, private business and international cooperation are perfectly compatible; successful

**"multinationals" are proof of this. It is true that until recently there were no multinational firms involved** in space developments (unless INTELSAT is seen as a business). Actually, space activities in practically all countries constitute an area where governmental setting of policy, financing, and implementation of programs are the rule, although the private sector can be expected to play an increasingly important role in future space activities.

There is a clear trend towards increased private-sector involvement in those applications of space expected to generate profit, and the matter of "space commercialization" is now being actively debated in the United States. **In Europe, precedents** have been set with firms like ARIANESPACE (for the sale of launch services) and SPOT-IMAGE (for the commercial exploitation of the French SPOT Earth-resources-sensing satellite). **In Japan, space programs rely on close government-industry interaction.**

Hence, if it appears that activities conducted using space infrastructure can be economically profitable, the fact that it was developed internationally should not present an insurmountable obstacle to private-sector involvement in its use. However, all other things being equal, it is likely that U.S. industry would prefer to deal with infrastructure owned and operated by U.S. interests, Government or private.

### THE ECONOMICS OF COMMERCIAL APPLICATIONS

The greater the prospects of commercial use of space infrastructure, the better the prospects for returns from investments made to develop it. The economic prospects can only gain from its large and wide-encompassing utilization. Such utilization, including foreign users, may exist even if the United States develops all or nearly all of the infrastructure. Many foreign customers would be attracted to any opportunities provided by its use. The extent of commercialization would then depend mainly on the conditions set by the owner(s) and operator(s): first and foremost, pricing policy, but also any commercial restrictions (e.g., will the infrastructure be made available to foreign firms competing directly with U.S. firms in a given field of application?) and technical factors (e.g., such stringent safety requirements that disclosure of proprietary knowledge would have to be made by the user). However, NASA's experience with accommodating commercial interests (including R&D efforts) on the Shuttle, through such mechanisms as Joint Endeavor Agreements and trips purchased in whole or in part by commercial interests under proprietary conditions, provides precedents which suggest that even U.S.-only elements could accommodate non-U.S. commercial users successfully.

It appears likely that international involvement in space infrastructure development, operation, and ownership would enhance the prospects for an economically efficient and broadly based utilization program. Common interest in its future capabilities and use will stimulate creativity and innovation among a much wider international community of potential users, including non-profit-seeking ones (governmental agencies, research institutions and the like). Also, any competition from the Soviet Union will be lessened if spacefaring countries feel secure in their participation in a U.S./international complex.

### THE TECHNICAL ADEQUACY OF POTENTIAL FOREIGN CONTRIBUTIONS

What components of space infrastructure would each of the potential partners reviewed earlier be most likely to contribute by virtue of the current tendencies of its own programs, of the existence of technological domains where its industry is known to excel, or of other factors? Answers to this question are important. For if any foreign partners enter such a cooperative effort, the United States must ensure that their technical contributions are feasible, compatible, and complementary. Or, from another perspective: to what extent would the desired infrastructure have to be modified in order to accommodate contributions by a given set of participants?

It is impossible now to suggest more than a few generalities, inasmuch as NASA has not yet specified what the overall performance specifications are going to be.

Too, the level of technical sophistication for a given subsystem cannot yet be articulated. As just one example, consider electric power conditioning and distribution. On all spacecraft developed until now, electric power is distributed at low voltage, and all spacefaring countries possess the relevant technology. Many experts, however, judge that, for long-term in-space infrastructure, this technology should be supplanted by an alternative, high-voltage technology. In anticipation of just such a development, ESA and NASA have been discussing for some time the generation of a set of standards to be employed in spacecraft high-voltage power systems; but the matter is still outstanding,

Lastly, potential participants may wish to make their contribution, not in the areas where their industry is best endowed with existing capabilities, but rather in areas where they want it to acquire new capabilities. Nothing should prevent them from doing so if they are ready to commit themselves to meet the costs of such new and (to them) risky developments. This matter could become "sticky," however, if they were to wish to make a "key" contribution in such an area, Thus, no useful projection of task allocation can be made now. Perhaps the division of work will have to be negotiated on a case-by-case basis, before the program actually starts, but after its shape and definition have been outlined in **more detail. Some countries are already suggesting ways in which they might prefer to contribute, and it would be wise for the United States to give careful consideration to including prospective partners in the infrastructure design phase in some sensible fashion.**

## Assessment: Pros and Cons of International Involvement

### A "U.S. ONLY" PROGRAM

At first glance, since almost certainly the United States is likely to bear the largest part of the financial burden of a "space station" development program, and since international cooperation is fraught with many well-known difficulties, it would seem that there would be much merit in the prospect of an independent, strictly U. S., undertaking. In addition, many of the reasons which have led the United States to consider a "space station" program in the first place—national pride and a sense of accomplishment, national prestige, national security, or supporting U.S. firms in commercial space activities—might best be served by a program carried out under exclusive U.S. control.

Similarly, it could be argued that potential international partners might find it to their advantage to be left to their own devices in planning and implementing their respective space programs, rather than having to weigh the pros and cons of associating themselves with what will in essence be an American program, unlikely to be perfectly suited to their goals and/or technical and financial resources and likely to limit their ability to pursue independent actions.

The arguments in favor of a strictly national U.S. program can be summarized as follows:

1, There is no substantial reason why the United States would not be able to go it alone: the country has all the technical and industrial resources necessary.
2. Generating and maintaining international interest in a "space station" program and enlisting participants is in itself a difficult process, leading to many concessions on the part of the United States and other participating countries, the return from which could be rather disappointing. Participation of Europe in major U.S. space undertakings, such as the Space Transportation System or the Space Telescope, seems always to stay in the 10 to 15 percent range, which is consistent with European space budgets. Even if one other major partner, say Japan, joins the "space station" program at a similar level, this still leaves the U.S. to bear 60 to 70 percent of the expense.
3. International cooperative programs, especially where advanced technology is concerned, have the reputation of being beleaguered by complex diplomatic and managerial interfaces, as well as by difficult compromises needed to tailor the overall undertaking to each participant's particular requirements.
4. Past experience points to the fact that the U.S. civilian space pro-gram is difficult enough to coordinate with the U.S. national security program on a purely national basis. This could be even more difficult in the case of an international "space station" program.

These considerations must however be carefully weighed against a number of arguments in favor of international involvement:

As stated repeatedly, international cooperation is a long-standing tradition in civilian space programs, and pursuing it has had a very positive political impact. Traditional partners of the United States in the industrialized world consistently list cooperation with this country among the objectives of their space policy statements; for example, the head of the French space program, who also chairs the ESA Council and the European Science Foundation, has recently noted that "cooperation with the United States is of fundamental importance."[38] The United States has given a strong impression already that it anticipates significant international utilization of a "space station" and that, in order to assure such utilization, it will be receptive to foreign participation i n the development phase of the program. A decision to forego such participation would certainly have major (though probably not yet **very** major) political costs.

2. As discussed earlier, if the United States chooses to go ahead alone with its space infrastructure acquisition program, several countries or groups of countries among the industrialized Western-type democracies are likely to follow suit, even if on a smaller scale and after some time. Such duplication of efforts might well result in a net loss to the Western world. The very cost of these investments is bound to generate an extremely harsh level of competition for their commercial utilization, to the point where it may not be economically sound any more and the benefits of space

[38] Curien, *op. cit.,* p. 76

commercialization could be lost or significantly delayed.

3. Even if the prospects that Europe and Japan may associate in a joint "space station" program without the United States seem remote, there is no doubt that this possibility becomes more likely if the United States chooses to go it alone. As argued earlier, there are virtually no circumstances in which Europe or Japan would refuse a U.S. offer of involvement in the "space station, " and thus it is up to the United States to decide whether to make that offer.

As argued earlier and briefly again above, a likely impact of U.S. decision to proceed alone would be the eventual development by other space-oriented countries of capabilities which will be, at least in part, similar to those offered by a U.S. "space station." This could result in increased downstream economic competition between the United States and other industrial countries in commercial exploitation of space. By involving potential competitors in the U.S. 'program, this situation might be avoided or minimized. There is a certain parallel with the situation regarding European involvement in U.S. post-Apollo activities. By **withdrawing the offer of European development of a space tug (with an estimated cost to Europe of $500 million—$1 billion) and substituting the Spacelab (then estimated to cost $100 million-$200 million), the United States made possible a European financial commitment to develop its own launcher, which is now competing with the Shuttle for launch contracts. The United States** needs to evaluate carefully whether it wants to create a similar situation as its "space station" program begins.

As mentioned earlier in this paper, from the U.S. perspective international involvement is an option, not a requirement. However, not only are there strong reasons for the United States to pursue this option, but, at least from NASA's perspective, internationalizing the "space station" program to some meaningful degree eventually may bean important means of gathering political support in this country for the size and kind of program that it wishes to have. If the nationalistic objectives which might be served by NASA's present "space station" program aspirations are not sufficient to gain White House and congressional support of a "go it alone" approach, then an approach mixing nationalistic and cooperative elements seems essential to mobilize political support for it.

## AN INTERNATIONAL PROGRAM

This approach to space infrastructure development, operation, and use would be preferred by the United States and/or other space-capable countries only if it was the best available means of maximizing all of the national objectives which have led to beginning the program in the first place. As mentioned earlier, the INTELSAT and INMARSAT analogy is rather misleading here. The objectives of those systems are inherently international in character and could not be successfully pursued without broad international participation, while space infrastructure can be developed and operated as a purely national enterprise.

Even the parallel to ESA is somewhat artificial: European countries created ESA because such a joint endeavor was the only way that they could marshal the resources required to carry out a comprehensive space program, albeit on a regional rather than a national basis. The United States, should it chose to do so, has the resources required for unilateral "space station" development.

A decision to create an international acquisition arrangement is highly unlikely, given the specific character of the support mobilized behind the "space station" concept in the United States, Europe and Japan to date. One fundamental motivation which could lead to such a decision–that it was the only way to mobilize the needed financial or technical resources—is missing, and there seems to be no other compelling reason, from a U.S. perspective, to pursue this option. Only if it were seen by the United States and, to a lesser degree, other spacefaring states as a particularly attractive way of symbolizing their commitment to broadly based international cooperation would a "fully international" option be preferred; no such vision has been persuasively advanced.

Making international operational arrangements once the infrastructure is acquired appears a somewhat more realistic prospect, though still unlikely to be preferred by its developers. The United States (and its partners) could recoup at least some costs of the acquisition by selling shares in it, and this form of broadened international involvement may be an attractive way of giving newly industrializing and developing countries a useful sense of involvement on the space frontier. Broader international involvement could also be accomplished by internationalizing (to some extent) the operating crew—or by leasing facilities to the rest of the world.

## A U.S. PROGRAM WITH INTERNATIONAL INVOLVEMENT

Since the United States has given strong indication that it will open its space infrastructure program to foreign participation, it is useful to estimate what form of involvement is most likely to be successful, where success is defined as a mixture of costs and benefits which is acceptable to all involved. Reaching an agreement is likely **to** involve difficult bargaining and significant compromise **at** the political, managerial, and technical levels. This process is already beginning, and both the United States and its potential partners (particularly Europe) **are** approaching the issue in **a** rather different manner than was the case during the 1969-73 negotiations over post-Apollo participation.

Those objectives which are likely to be of most interest to the United States perhaps would be best served by a cooperative approach which would commit the United States and its partners to share important parts of the overall acquisition program, to remain involved beyond its acquisition (i. e., during its operational phase as well), and to seek broadly based infrastructure utilization once established: that is, overall **joint acquisition, operation, and use. Certainly the United States would prefer to be the world leader in space development and use over the next few decades. A U.S.-led, freely arrived at, major in-space infrastructure collaboration program–one involving many, perhaps all, countries, especially the major spacefaring ones—would go a long way toward achieving this goal.**

But it seems as if the objectives, primarily utilitarian, which would motivate other countries to join in such a U.S. program **would be best served** if they could do so with minimal loss of their future freedom of action—i.e., participation in the acquisition, including development, phase only, with no a priori commitment to system utilization or to sharing in overall system management.

Potential U.S. partners are, of course, fully aware that a U.S. offer to share in the acquisition of in-space infrastructure is fundamentally political in character, and that decisions on issues such as cost-sharing and division of labor are as much political as technical or economic. However, as the earlier review of the space programs of potential partners has suggested, Europe (both ESA and individual countries) Canada and Japan **will bring some very real assets to the negotiating process.** The outcome of that process is certainly not going to reflect U.S. interests alone. Indeed, Europe, Canada and Japan may consider their participation in the operation of the infrastructure and their guaranteed access to it as preconditions to their contributing to its development.