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THE ADMINISTRATION OF THE NASA SPACE TRACKING SYSTEM

and

THE NASA SPACE TRACKING SYSTEM IN AUSTRALIA

by

Neil Hollander

National Academy of Public Administration Foundation

January 31, 1973

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PREFACE

In the summer of 1968, the National Academy of Public Administration undertook for NASA, under contract NSR-09-046-001, a study of the international activities of the space program. The effort focused particularly on NASA's development of tracking sites around the world through which space craft could be monitored and controlled. The establishment and operation of these stations were of interest to the Academy because of the relative success of the operations, the variety of administrative environments in which stations operate, and the use of highly sophisticated communications technology to tie together, in a centralized organizational structure, an enterprise physically located in many different countries. Of additional interest were questions concerning the transfer of technological capability from one culture to another and how a U.S. agency such as NASA could convince other countries not only to permit the location of stations on their soil, but also, in many instances, to operate all or part of them.

The purpose of this study was to record what has been a highly successful management program and to communicate to a broader audience some critical points about cross-cultural management and the relationship of technology to organization. Field research was to be an integral part of the study and visits to several different countries were planned. Unfortunately, except for Australia, the planned visits could not be arranged and the original, broader design of the study had to be abandoned. However,

enough information about operations has been collected to make some limited generalizations possible, and they, together with the one field study of Australia completed in 1969 and recently updated, comprise the body of this report.

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INTRODUCTION

Since the late 1950's as part of the space program, NASA has developed and maintained a series of tracking stations around the world. The significance of this enterprise for the space program cannot be overestimated since "a space-craft with the finest scientific instruments, launched perfectly into orbit, is worthless unless it can be tracked and its scientific information recorded at ground stations."[1] However, another aspect of this effort--its organization and administration--may be of equal importance to those responsible for U.S. bilateral activities and to those generally interested in cross-cultural administration.

Despite the technical need for ground stations in the space program, there is no preordained manner in which this requirement is fulfilled. In fact, there are at least three major tracking networks around the world, all administered in a different fashion. One, operated by the U.S. Department of Defense for military purposes, utilizes only United States personnel. It is highly classified and closely related to military ties abroad. The second, managed by the Soviet Union, is operated entirely on Soviet soil or on specialized tracking ships manned by Russians; therefore, it is of little interest to those concerned with management in different cultural environments. The NASA system, which includes tracking stations, ships, and airplanes, is located throughout the world in many different social, economic, and political environments. It utilizes local nationals,

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1. J. T. Mengel, "Satellite Tracking, Telemetry, and Communications," Electronic World, LXXI (June, 1964), p. 58.

U.S. and foreign contractor personnel, foreign government employees, foreign university employees, and a small contingent of NASA staff. The stations are tied together by a communications system (NASCOM), which, together with essentially common equipment in the stations, is designed to provide for NASA an identical product irrespective of the station from which it is received, recorded, or transmitted.

The experiences of developing and operating this system characterized by environmental diversity and differing administrative patterns are important to policymakers and public administrators alike.

HISTORICAL DEVELOPMENT OF NASA TRACKING STATIONS

To comprehend the operation of the NASA tracking stations, it is necessary to understand their purpose and historical evolution. Tracking stations have existed as a critical part of the space program since its conception. Their function is to link objects in space to facilities on earth so that orbits may be computed and verified, scientific information collected, and communication, command, and control maintained. Normally, they are located in relatively isolated areas where their communications and tracking equipment can operate without interference from other communications facilities. They are relatively self-contained units consisting of (1) tracking antennas (similar to a radar device), (2) communications equipment to link the station with the objects being tracked and their control center, (3) computers programmed to operate much of the complex equipment and to store data, and (4) maintenance and other support facilities to insure smooth operation. Normally, a station has a complement of a hundred or more people divided into shifts to operate it. Most of these people are electronics, computer, and communications technicians, but there are also facility engineering, administrative, and support personnel to direct and maintain the station. The station is tied into its control center through a complex communications network established around the world. This system, designed to provide instantaneous communications with a high degree of operational reliability, originally utilized land communications, radio transmissions, and undersea cables, but increasingly it is using communications satellites placed in synchronous orbit above the earth.

Historically, NASA has operated three separate tracking networks. Of the three, only one (manned space flight) was developed substantially

within NASA. The others trace their origins to the U.S. armed services which originally oversaw the space program. The responsibility for the establishment and operation of the Deep Space Flight Network, which tracks U.S. unmanned space probes, was inherited from the Department of the Army as a part of the overall transfer of the Jet Propulsion Laboratory and the Army's space program to NASA. The STADAN Network, (now consolidated with the Manned Space Flight Network (MSFN)), which is utilized primarily for tracking earth-orbiting satellites, came into NASA as a part of Project Vanguard when responsibility for this program was transferred from the Naval Research Laboratory to NASA. The roots of all of these systems lie in the tracking range experience gained by the U.S. military during World War II when radar and related electronics were first used for telemetry and tracking of military rockets.

NASA's present space tracking organization consists of the Office of Tracking and Data Acquisition (OTDA) and elements of two field centers. The Office of Tracking and Data Acquisition has the prime responsibility for overseeing the operation. It is concerned with (1) basic policy decisions, (2) securing and allocating financial resources, and (3) maintaining technical and operational liaison with designated agencies of the host countries. A second headquarters staff organization--the Office of International Affairs--has, as a part of its responsibility, the task of working with the OTDA and the State Department to negotiate and maintain tracking agreements and managing other diplomatic concerns. The two field centers--the Goddard Space Flight Center and the Jet Propulsion Laboratory--oversee the actual installation and operation of the stations and serve as the location for the control centers. At present, due to a consolidation in 1971 of the MSFN and STADAN,

there are two tracking networks. One is located at each of the above field centers with a control center for manned space activities located at the Manned Space Flight Center at Houston. There are approximately 9,100 people directly involved in this operation worldwide: 79 percent are U.S. nationals and 21 percent are from other countries. In the foreign stations there are 22 percent U.S. nationals and 78 percent host country nationals. As of 1972, NASA had a $680 million investment in the space tracking system.

Spacecraft tracking was initiated in 1957-58 during the International Geophysical Year and in connection with Project Vanguard. Under this program, the first U.S. satellites were launched into space. To monitor them, a north-south "tracking fence" was established in North and South America. Its primary functions were to demonstrate that orbits had been reached and to collect scientific information. As the space program expanded, so did the mission of the stations. In fact, some of the original stations built during this period are still functioning, although they are much more sophisticated technologically and are utilizing staffing patterns of a different nature. The original stations were staffed by military personnel, usually from the Army Signal Corps.[2] Today, they are civilian operated with various combinations of NASA, private contractor, and local staff.

In addition to the Vanguard stations, many space tracking sites were developed during the International Geophysical Year for the purpose of tracking other satellites. A series of stations on an east-west axis was established to provide support for all launches from Cape Kennedy and for

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2. Interview with J. R. Mengel, Assistant Director for Tracking & Data Systems, Goddard Space Flight Center, February 27, 1969.

anticipated deep space flight missions. Originally, these stations, as well as the Vanguard stations, were located in temporary movable vans. It was not until the civilian space program was institutionalized by the creation of NASA, that the tracking system organization was established.[3]

In many respects, the development of the tracking system parallels the experience of NASA itself. The absorption of existing organizations, the move to civilian operation, the use of private contractors, plus the centering of policy at Headquarters and of operations at field centers were all a part of the development of the larger organization. This meant that the application of similar techniques in regard to problems of an international character was not seriously challenged within NASA since the general attitude of the agency encouraged experimental techniques of operation. The result throughout NASA was an achievement-oriented environment, characterized by operational flexibility, which was linked with a well established technical mission and the supportive national goal of a serious thrust into space.[4]

In terms of the tracking operation, the typical features of a bureaucracy, such as the routinization of work and specialization of activity, were avoided by assigning to technical administrators the responsibility for design, operation, and administration of the system. This facilitated the rapid construction of new stations, the most noteworthy example being the Project Mercury Network (later to become the Gemini and then the Manned

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3. Interview with Edmond C. Buckley, former Associate Administrator for the Office of Tracking & Data Acquisition, NASA, February 19, 1969.

4. For a discussion of the philosophy of management which existed at NASA during most of this period, see James E. Webb, Space Age Management, (New York: McGraw-Hill Book Co., 1969).

Space Flight Network), which was constructed and put into operation within two years. NASA's efforts on Project Mercury involved the overseeing and coordination of five major U.S. contractors and their employees, the negotiation of operating agreements with several governments, the training of several hundred station personnel, and the construction of 19 stations throughout the world. All of this occurred during a favorable funding climate when the heavy financial costs of such a crash operation were more readily accepted.[5]

The development of the tracking network involved more than the problem of constructing and manning tracking sites. In order to accomplish these things, international agreements had to be made with a number of countries. Both the U.S. State Department and NASA's Office of International Affairs played an important role in concluding them. These organizations, along with the Office of Tracking & Data Acquisition and the field centers, worked together to negotiate the agreements. In choosing countries in which to locate stations, NASA determined the proper geographic area, the U.S. State Department chose the most politically acceptable countries within this geographic area, and both organizations participated in the actual negotiations. Since time was a crucial variable, the operating philosophy was to negotiate on as flexible a basis as possible, making agreements to fit each individual situation.[6]

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5. Thus the original award for the network of 33 million dollars became 60 million dollars by the completion of the task. See NASA Office of Scientific Technical Information, NASA SP-4001, Project Mercury A Chronology (Washington, D.C., 1963), p. 129.

6. For example, in Chile, a cooperative arrangement was achieved with a university. In Mexico, a joint Mexican-United States Commission was established to oversee the station. In Australia, the stations were to be operated by the Australians through one of their own government departments with only a small number of NASA liaison and coordination personnel.

PATTERNS OF OPERATION

While an individual set of relationships evolved in each country, three significant patterns of operations emerged, each one reflecting different environmental circumstances. The first, which uses all U.S. personnel, is typical of many U.S. government activities abroad. This method is employed in situations where NASA felt that the language difficulties or technical competence within the host country was such that stations could not be operated by local nationals, or in instances where there was virtually no indigenous population, as in a number of the isolated island stations. The primary characteristic of this pattern is the somewhat unusual utilization of private enterprise to perform this function.[7] Typically, in cases where this appraoch is followed, there are one, or perhaps two, NASA station directors associated with each station. The station director is responsible for maintaining official contact with the host government, officially representing the station, and directing its operation by the use of a private field engineering firm. In addition, the worldwide NASA communication system is operated through industrial contracts. Thus, while NASA employees have formal control of the tracking system, the actual operation is undertaken by persons not formally employed by the U.S. government.

The second pattern relies upon personnel provided by the host country itself. It is the responsibility of the country to operate these stations under the direction of NASA, in effect utilizing agencies of these countries as

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7. This pattern of operations is also followed by the Department of Defense for its tracking stations throughout the world.

contractors. In developing this pattern, each government was convinced by the United States that a number of advantages would accrue to it through its participation. The advantages for the host country were described as (1) an important way to participate in the exploration of space, (2) a contribution to good political relations with the United States, (3) a way of providing important technical and scientific spin-off to the host country, and (4) a way of providing important economic benefits.

Until recently, stations operated in this manner were confined to Commonwealth or English-speaking countries with recognized technical competence.[8] In fact many of the actual operators at the stations were born in the British Isles and attracted to other countries by the advantageous working conditions (both technical and financial) at the stations. Recently, other countries have begun moving to this pattern. This is significant for two reasons: (1) it is the first time that countries with non-English speaking backgrounds have been given full responsibility for operating stations; and (2) it will be the first instance where countries have developed the capacity fully to operate stations. In the past, countries which operate stations had, at the outset, the basic technical, linguistic, and managerial capabilities for integration into the NASA system. An example of this is one of the two Spanish stations (Madrid), which is moving quickly in this direction with the station's operation being placed under the direction of that country's Instituto Nacional de Tecnica Aeroespacial.

The foreign government operating mode is an important form for the operation of the overseas tracking system. In terms of the number of people employed, it is the most prevalent pattern. Australia, for example, has the single largest tracking operation outside the United States

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8. The countries in this group are England, the Republic of South Africa, Australia, and Canada.

supporting the deep space, manned, and unmanned networks. It has a management structure which includes a large central organization responsible for administering all the stations within the country, irrespective of the network to which they report. In addition, this pattern is important as a model for the tracking system, since NASA's operating strategy has been to move from stations operated by U.S. private contractors to foreign government-operated stations.

A third pattern of operating relationships provides for gradual reduction of U.S. personnel as technical competence is gained in the local environment. Presently, tracking stations in most of the countries are operated in this manner. The number of local employees ranges from 12 percent at Ascension Island to 94 percent in Chile, where the station is virtually the responsibility of the University of Chile.[9] However, the percentages, particularly those that are quite low, often represent maintenance and low skill personnel and to that extent, the ratios indicated in Figure 1 (see page thirteen) do not represent local technical involvement in the stations. On the other hand, they do indicate significant increases over the years. In cases where this style of organization is followed, there generally is a NASA station director, U.S. contractor personnel, and local staff employed by the U.S. contractor. Both NASA and the U.S. contractor have seen the U.S. contractor's role as "working itself out of a job" by turning as much responsibility as possible over to the local nationals.[10]

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9. See Figure 1. Statistics supplied are from the Office of Tracking & Data Acquisition, NASA.

10. Virtually all of the contracts awarded for operating the stations have been awarded to the Bendix Field Engineering Corporation. This is not necessarily because they are considered as a sole source, but because they have been able to outbid others who might be interested. After winning the first round of bidding, Bendix had a decided advantage in subsequent bids since it did not have to face start-up costs as would other concerns.

FIGURE 1

Percentages of Foreign Nationals Employed at NASA Space Tracking Stations Through Fiscal Year 1972.*

Country	Percentage		
	1967-68	1969	1972
Antigua	24	27	Closed
Ascension	0	3	12
Australia	100	100	100
Bermuda	42	36	43
Canada	100	100	Closed
Chile	70	80	94
Ecuador	53	60	65
England	80	100	100
Grand Bahama	10	11	Closed
Madagascar	43	48	65
Mexico	39	35	Closed
Peru	93	97	Closed
South Africa	100	100	100
Spain	56	56	81

*Statistics supplied are from the Office of Tracking and Data Acquisition, NASA.

All the patterns used to operate the tracking stations have a common purpose--to sustain the continued utilization of tracking sites with high technical reliability over a period of time. The choice of pattern relates quite closely to the kind of environment in which a given station exists, and a conscious effort is made to insulate a station from the broader political environment. In countries where a friendly, stable relationship has persisted over a long period of time (Australia and England for example), there is less concern with political considerations and more emphasis on the benefits to be derived from the operation. Even in these countries, however, there is a continuing emphasis on the nonmilitary aspects of the space program. In the areas in which bilateral relationships are more volatile, for example, in the Latin American countries, the use of host country nationals and the emphasis on the civilian character of the stations constitute an attempt to remove them from the political arena. The strategy followed has been to give the station a base of local support which would enable it to overcome any political difficulties that might arise.[11]

NASA has been able to continue uninterrupted operations over long periods of time in countries such as Peru, Chile, the Malagasy Republic, and the Republic of South Africa. It could be argued that the inherent attractiveness of participation in the space program alone would guarantee continued success; however, the NASA policy has reinforced the feeling of

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11. Interview, Mengel, loc. cit.

participation on the part of countries and, perhaps, has been crucial to sustaining operations in many of them.[12] While none of these countries can be classified as extremely hostile, in some, a U.S. label is not a distinct asset; yet, these stations have operated side by side with others located in more congenial environments and with those in the United States.

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12. NASA has only had to abandon one station--in Zanzibar--when a revolution brought in a government which was highly nationalistic and hostile to all U.S. activities on the island. It is doubtful if any kind of operational arrangement could have altered the outcome in this case. However, it is interesting to note that President Karume of Zanzibar subsequently publically stated that he had been wrong in suspecting the NASA station of improper activity.
NASA also has closed stations in Australia, Peru, Chile, Mexico, Canada, Grand Bahama Island, Canton Island, and Antigua, as well as in the United States, largely because technical requirements changed.

FACTORS AFFECTING STATION OPERATION

In appraising NASA's tracking stations, it should be stressed that there are two quite different, but seemingly reasonable, views of the difficulties encountered in establishing the system. One treats the effort as routine and uncomplicated, with very little importance attributed to the organizational and political factors involved in the operation of the system. This view is expressed as follows:

> "...the tracking network has been relatively easy to establish and maintain...there is widespread evidence of almost universal willingness, if not desire, to obtain tracking stations."[13]

The other emphasizes the magnitude of the concessions made to the United States in permitting stations to be established in foreign lands and suggests that there is something uniquely successful about the NASA operation. It is characterized as follows:

> "The installation of such a station requires the host country to accommodate the United States equipment and personnel on its own territory and to make available radio frequencies for the station's use in communicating with satellites and in some cases with a control center in the United States...(that) to appreciate this accommodation, it is necessary only to know that United States law denies the possibility of such arrangements on behalf of foreigners except in very restricted circumstances. Nevertheless, NASA has never been denied access to any desired location."[14]

In spite of the different attitudes about the difficulties of establishing the tracking system, both views consider the civilian peaceful character of

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13. Don E. Kash, The Politics of Space Cooperation (Purdue Research Foundation, 1967) pp. 66-67.

14. Arnold W. Frutkin, International Cooperation in Space (Englewood Cliffs, New Jersey: Prentice Hall, 1965) p. 70.

the tracking operation as playing a significant role in the success of the enterprise. Yet other U.S. activities abroad, notably in the area of technical and economic assistance, have similar characteristics but nonetheless have not operated with a comparable degree of success. This does not mean that the difficulties of establishing tracking stations can be equated with the problems of mounting a successful technical assistance program. Achieving results in the latter instance involves a much more fundamental impact on a society. However, the process of organization in both instances has certain common features, and the NASA experience certainly stands out as an important success. Some of the reasons for this success are summarized below.

Flexibility of Operation

The most important of the factors contributing to the success of the tracking system is the organizational flexibility displayed in establishing and operating it. Without an approach which tolerated diversity, it is unlikely that the system could have been as quickly or as effectively developed since the technical demands of the tracking system are for a common product from a highly centralized technical operation, while geographically the stations are located thousands of miles apart and are operated by a variety of organizational patterns in a number of cultures. Thus, in Australia, a New Zealand immigrant, working for an Australian electronics firm, which has subcontracted with the Australian government, which in turn has contracted with NASA to operate a station, might be working in conjunction with a French-speaking Malagasy technician, trained in a NASA electronics school at a station in Madagascar, operated by a U.S. private contractor, and both of them could be dealing directly with an employee of

a private U.S. contractor employed by NASA to operate the control center in the United Sates. The variety of these relationships is almost infinite and demonstrates that, even on an international level, it is possible for public administrators to produce a common product and to decentralize the means of obtaining it while taking into account the unique characteristics of local environments.

This factor of flexibility had several important effects. It enabled NASA, simultaneously, to operate stations in technologically developed and less-developed countries. It facilitated operations in countries where the political environment was subject to rapid change and provided for rapid opening and closing of stations as tracking requirements changed. In this regard, the use of private contractors by NASA and the Australians is significant because the problems of civil service tenure and slow organizational response have been minimized by using the contract device as a means of securing services which, of necessity, are subject to rapid change.

The reasons NASA followed this approach are less easily analyzed. One could argue that, given the international environment in which the stations were established and the need to set them up quickly, it was unlikely that any other approach could have succeeded as well. While, in retrospect, this may be true, it certainly took effective organizational leadership to recognize the value of this approach and to institutionalize it as a standard pattern of operation.

Undoubtedly, another important factor was the relative youth of NASA as an organization. In this period of development and of organizational pattern setting, NASA itself had not established rigid controls over

its activities which might inhibit innovation. Rather, the technical administrators, indeed often the technicians themselves, were responsible for basic decisions ranging from location to procurement to operation of the stations. It is unlikely that this would occur in more established organizations, and it is widely felt that they would be unable to do the same job today under present conditions. One of the interesting questions about the future of tracking operations is whether, as the original leadership departs and as these very successful patterns become routine, the new leadership will institutionalize the process of flexibility or utilize the solutions that flexibility produced in attempting to meet environmental conditions.

Involvement of Host Countries

An aspect of the organizational flexibility factor has been the policy of involving the host country and its personnel in station operations. A variety of agreements have been used to accomplish this but certain characteristics are common to all. In almost every instance, NASA established ties with scientific and technical organizations within the host country. These organizations varied from those created especially to work with NASA, such as the Mexico-U.S. Commission for Space Observations, to ties with existing organizations, such as the University of Chile's engineering faculty and the Australian Department of Supply.[15]

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15. The scientific organizations which NASA has dealt with over the years include the United Kingdom's Science Research Council, the Instituto Geofisco del Peru, the Canadian National Research Council, the Spanish Instituto Nacional de Technica Aeroespacial, and the Council for Scientific and Industrial Research in the Republic of South Africa.

Because these organizations became directly involved in the operation of the stations, they developed common interests and goals with NASA, often representing important support for the space agency within the host government. They also contributed to strong support in many of these countries for the U.S. space program and for continuing their own involvement with tracking stations. Even in Chile, where relations with the United States have significantly deteriorated over the past few years, President Allende was reported, upon taking office, as supporting the continued existence of a station in his country, since this was the kind of cooperation with the United States that his country desired. It is unlikely that the depth of support which exists for sustaining the stations would exist without such institutional involvement and the use of host country nationals. Undoubtedly, this pattern of cooperative organization also contributes to a positive view of the United States and aids relations between the involved governments.

One important economic and administrative benefit of not using U.S. nationals is that operational costs are significantly lower than they would be if only U.S. contractor or government personnel were used. Not only does this save money in salaries, but it also minimizes the problems of supplying and maintaining Americans abroad. In fact, this type of cooperation has the double virtue of positively involving the host country in station operations and minimizing the negative impact of Americans living abroad under artificial circumstances.

The policy of involving host country nationals is not without problems. Inevitably comparisons are made of U.S. and host country standards of remuneration. This leads to a feeling by a few station employees that they are being exploited by NASA although this has never become a major

issue and is minimized by the policy of having as few U.S. nationals as possible working abroad. Also, NASA has taken a hard line towards hiring only well-qualified host country personnel. In countries where the requisite skills are scarce, host country involvement has been slow. In some cases, there has had to be a give-and-take between the host country and NASA about how quickly host country nationals could fill positions at the stations. However, there is no doubt that NASA's leadership has been committed to this policy, and the statistics indicate their increased succes in implementing it.[16] Certainly, the involvement of foreign nationals has increased the probability that NASA can maintain stations for as long as it desires, including those in sensitive countries such as Chile, the Malagasy Republic, and the Republic of South Africa.

Emphasis on Benefits to Host Countries

Another reason for NASA's success is that host countries have been convinced they would benefit from accepting the location of a station in their country. NASA administrators have always emphasized this point, suggesting such a broad range of benefits that at least some must occur.

One of the benefits always stressed by NASA is that, by having a station, the host country would be able to make an important contribution to space exploration without having to make the investment that only the superpowers could afford. The importance of this suggested benefit to the host countries is hard to judge, but the political speeches and newspaper articles in many of the countries indicate that host country involvement is strongly felt and appreciated. NASA also makes available to the host country

16. There have been some interesting indirect effects of this policy. For example, in Peru, the NASA station provided intellectual and financial stimulation to several people directly involved in space tracking, enabling them to complete advanced graduate work and make the Instituto Geofisco one of the most preeminent scientific institutions in Latin America.

all the scientific data collected by the station, although few countries have taken advantage of the opportunity as huge investments in men and equipment are required to exploit the data. However, the impact of the availability of information should not be underestimated. This "freedom of information" feature has even had direct political consequences. In Mexico, the fact that there was access to data and that Mexicans were directly involved in the communications process defused charges that the station was being used for military purposes and should be removed.

Another benefit which NASA often stresses is the potential for scientific and technological transfer of advanced tracking knowledge. From this perspective there have been some important advantages of participation. In a few countries scientific experiments have taken place, often cooperatively undertaken by scientists in the United States and the host country using the stations in both countries. However, their number is limited for two reasons: (1) the operating costs are extremely high, even though NASA does not charge for using the stations, and (2) they are often unavailable because they are being used for NASA tracking purposes.

The most important transfer benefits are probably in the area of technical knowledge with advantages accruing to countries in all stages of technical development. The more advanced countries benefit by having their own engineers and technicians exposed to "state of the art" communications systems and to computer and electronic equipment. In Australia, which encourages immigrant employment at the stations, technical people from other Commonwealth countries have been attracted, thus meeting a broader national goal of increased immigration of people with these skills. In the less-developed countries, NASA has initiated basic technical training programs

for its local employees, developing critical competences which are often in short supply.

There are a number of important indirect technical benefits. The development of communications in many countries has been enhanced by locating the stations on their soil. In fact, the entire international satellite communications system has been stimulated significantly by the need to support the stations. In some cases, the NASA equipment has been extremely important, as in Madagascar in 1966 when telemetry from a NASA weather satellite gave early warning of an approaching cyclone.

One area from which several countries hoped to benefit, but which has not materialized, is in the expansion of their electronics industry. Except for a small movement of personnel from the stations to the electronics and computer industries (which may have significant long-term effects), very little industrial development in host countries can be related to the stations. The size of the tracking operations has had a great deal to do with this--no one station or group of stations generates enough demand for equipment to encourage the development of a manufacturing capability to support it. Also, the NASA concern for the system's integrity leads it to make most procurements from the United States.

There are two speculative aspects of the technology transfer question which are quite important. One concerns the benefit of increased access to worldwide scientific and technical information through participation in the tracking system. Not only does this create a better understanding of the equipment utilized, but it also provides an informal source of information to scientists and engineers about participation in other NASA projects. The second relates to the benefits derived from participating

in this unusual method of project management. Undoubtedly, some of the good points of NASA management are observed, modified, and adopted. In Australia, for example, a shift from civil service operation of stations to the private contractor mode was greatly influenced by NASA's management experience. This has resulted in a great deal of flexibility, not typical in Australia, of adding or reducing staffs as tracking requirements change.

Economic benefit is another reason often suggested to induce countries to participate. NASA pays for the operation of the stations, although some of the host countries voluntarily contribute funds, including much of the cost of developing the communications infrastructure to support the stations. Further, in countries where foreign exchange is important, these stations are a source of some earnings.

In summary, there does seem to be significant benefit to host countries. The importance, from a management perspective, lies in the fact that NASA has recognized the value of emphasizing the benefits. Instead of resting on the early enthusiasm that was generated for participating in the space program, NASA managers have continued to emphasize a wide variety of benefits.

THE ROLE OF COMMUNICATIONS IN THE TRACKING ORGANIZATION

One of the most important aspects of the tracking experience is the role of communications. NASA's facilities for communications are such that the stations in any network can be in immediate contact with each other, and all are in constant communication with their control centers. From NASA Headquarters in Washington, D.C., and other installations throughout the system, it is possible to speak to any station in the world as quickly as it is to make a regular telephone call. This ability to communicate rapidly has an important effect on the structure of the system and the ability of NASA managers to give technical and administrative direction to it. This demonstrates an important facet of administrative theory showing that, "Communications is the cement that makes organization" and "Communications alone enables a group to think together, to see together, and to act together."[17] Of particular interest is the role that technology played in enabling NASA administrators to shape the kind of organization they wanted. For while "It is communications, that is, the ability to transmit messages and to react to them, that makes organizations....,"[18] in this case the technology itself was a critical factor in shaping the administrative system. It provided the capability of real time communications with any station in the world and the potential for bringing together, in a highly centralized decision-making structure, all of the suborganizations (tracking stations) which utilized many methods of implementing decisions. That NASA was able

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17. See Karl W. Deutch, The Nerves of Government (New York: The Free Press, 1966) p. 77.

18. Ibid.

to organize its tracking organization this way is a tribute to the administrative skills of its staff; that it could do so is as much a function of the technology as of the administrative factors of flexibility and farsighted management. However, because of the expensive, complex technological communications system, the NASA tracking organization's particular structure may not be easily adopted by other international or multinational organizations. The approach, however, as well as an understanding of communication in shaping such organization, is important to those interested in management.

One of the central factors in this particular kind of communications structure is the effect it can have on organization loyalties. The constant direct communication between the tracking stations and NASA's field centers and headquarters operations enhances loyalties to NASA and the tracking system. This has led to the interesting phenomenon of a culturally varied force extremely loyal to one organizational system. In fact, the communications system and tracking organization that have grown around NASA operations have transcended the national barriers between the countries involved and, organizationally, penetrated their culture in a way that could not be accomplished through normal diplomatic, social, and commercial relationships.

CONCLUSIONS

A review of the experience gained in developing a worldwide tracking network demonstrates some important factors in public administration. One is the significance of organizational development versus organizational control strategies in establishing an organization, particularly in relation to the type of objectives sought. Public administrators, especially those educated and working in the western world, when faced with the need to create an organization, often have as their concern the question of how that organization can be controlled and made accountable in a narrow sense.[19] When this occurs, the goals of the organization can become a secondary objective, overshadowed by considerations of precedent and concern for controlling money and personnel. This may be an acceptable approach in situations where an organization is being structured to meet a relatively simple goal and where the environment in which it must operate is expected to remain unchanged. Where the opposite is the case, and when the goals of an organization are to substantially alter its environment, a development strategy requires an emphasis on objectives.

The most effective organization in this situation is one which provides an innovative climate, characterized by flexibility in operations and a relatively non-hierarchical communications process. Planning and operations have to be closely integrated with minimal separations between the two functions, and a cosmopolitan atmosphere must exist where administrators are adaptive and able to see the effects of their actions on others.

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19. See Victor A. Thompson, "Administrative Objectives for Development Administration," Administrative Science Quarterly, Vol IX, No. 1 (1964), pp. 91-108.

Organizations which have these characteristics are becoming increasingly necessary in the industrialized world as well as in the less developed countries. When they exist in a favorable political and funding environment it is possible to achieve a great deal. Certainly this was the case with the tracking stations and the space program during the 1960's.

In spite of the fact that few public administrators work in environments as favorable as NASA's, it does not mean that this experience does not have general applications. For example, some administrators in the U.S. AID program and in multinational technical assistance organizations, fear they cannot take the kinds of organizational risks to bring about the radical change necessary to be goal oriented; rather they involve themselves in organizational control and survival. An important lesson of the tracking station experience is that organizational age and the degree of bureaucratization are only some of the factors to be considered in determining whether developmental goals can be met, since it is evident that quite significant changes can be brought about through older, more established bureaucracy. The Department of Supply in a British Commonwealth country, an engineering faculty in a Latin American university, and government scientific organizations in many countries are not the kinds of organizations that would normally be expected to participate in radical administrative change. Yet, NASA, with a flexible but responsible approach, was able to work with these traditional organizations so that collectively they were able to overcome some unique and difficult technical and organizational problems. Thus it is possible that a developmental organization strategy can be used by a variety of existing organizational structures to meet developmental goals.

THE NASA SPACE TRACKING SYSTEM IN AUSTRALIA

By

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INTRODUCTION

This study, which examines the operation and administration of NASA's tracking stations in Australia, was undertaken in mid-1969. It was to be one of several case studies scheduled to be part of a larger study of the worldwide NASA tracking system. Unfortunately, it was impossible to arrange field visits to other overseas stations, and the research had to be significantly modified. However, this report on Australia was written as an independent document and is intended to be of use by itself. Since 1969, some of the facts surrounding the tracking operation have changed, and where it was possible, without another field visit, the text has been adjusted. The conclusions have not been modified and can be judged by readers with the advantage of hindsight.

It is useful to understand why Australia was singled out for this study. The basic reason was that tracking operations there represent what might be termed as NASA's "ideal model." The stations in this country are operated by the host country for the U.S. space program, and it has been NASA's stated goal to maximize working relationships of this character.[1] Australia also is typical of a number of other countries which have had NASA tracking stations located on their soil, and which together represent a

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1. See Gerald M. Truszynski, "International Benefits of Cooperative Tracking and Data Acquisition Agreements," United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, Austria (July 10, 1968), for a discussion of characteristics of the typical working arrangement.

large part of the overall tracking operations.[2] Characteristics of these countries are a common English language, a similar British heritage, a Western orientation in culture and politics, and a high technical competence.

There were some aspects of space tracking in Australia which were unique and justified choosing to do the study there. Australia is the largest and, organizationally, the most complex NASA tracking operation outside of the United States. It is the only country in which NASA operates abroad where there is a large management structure with responsibilities for operating stations over a widely dispersed geographic area. Presently, there are four stations in operation, but in the past there have been as many as seven. It is also the only country in which NASA operates stations from all three of its networks.[3] While there are countries in which NASA has stations for more than one of its tracking networks, the operations in those countries are not as extensive or as organizationally developed as in Australia.

To undertake this study, the relevant files of the National Aeronautics and Space Administration have been reviewed, and interviews have been held with the participants in space tracking in both the United States and Australia.

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2. These countries include England, Canada, and the Republic of South Africa.

3. The three NASA space tracking networks are the STADAN, Manned Space Flight, and Deep Space. The STADAN and Manned Space Flight Networks have recently been merged administratively into one. The Smithsonian Optical Network, which is paid for by a grant from NASA, is not, for the purposes of this study considered a NASA tracking network.

THE AUSTRALIAN ENVIRONMENT

Before examining the operation of the tracking enterprise, brief consideration must be given to the broader environment in which the stations operate. Many of the reasons for particular decisions affecting tracking are directly attributable to factors arising from the overall Australian milieu.

Australia is approximately the same size as the continental United States with a population of more than 12 million people. It has vast economic resources that are just beginning to be fully utilized. Despite the low population, it is essentially an urban society; Australia's major problems in continued economic growth are a lack of people and water. The economy is geared to full employment, and historically there have been more jobs than people to fill them. The political system is structurally a mixed federal/parliamentary form of government with a great deal of authority for domestic affairs lying within each state. The central (Commonwealth) government consists of a highly autonomous, protected civil service (similar to the British system), a bicameral legislature which, because of the system of apportionment and voting, is over-representative of rural interests, and an executive made up of a prime minister and 24 cabinet ministers drawn from the Parliament. The legislature has few permanent committees, and this, coupled with the rural bias of many of the members, has led to little parliamentary interest in science and public policy issues. The civil service, because of its expertise and interest, generally has assumed responsibility

in this area with cabinet members providing policy direction.[1] Since World War II, the position of the government has been relatively constant with a coalition between the Liberal Party and the Country Party dominating the Federal political scene.[2]

Government support of science has largely centered around government laboratories, staffed and run by civil servants.[3] Most non-defense research and development is undertaken by the Commonwealth Scientific and Industrial Research Organization (CSIRO) which itself is staffed by civil servants. Relatively little work is performed outside of these organizations, with universities and industry playing a minor role.[4] However, research funds seem to be utilized effectively, at least, if scientific productivity is any gauge. The country ranks tenth in the world in this respect among the 14 nations that produce 90 percent of the world's output,[5] while in 1960, her

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1. For an expanded discussion of these issues see Gerald E. Caiden, The Commonwealth Bureaucracy (Melbourne: Melbourne University Press, 1967), pp. 6-26; Carl J. Friedrich, Constitutional Government and Democracy (Massachusetts: Blaisedel Publishing Company, 1968), pp. 213-224, 387.

2. This was almost upset in the October, 1969, elections when the Labor Party came within a few seats of controlling the government. In 1972 the Labour Party did come to power; however, the long run effect of a party change in government on U.S. activities in Australia is uncertain.

3. The percentages of total government research budget spent in government laboratories in 1960 was about 85 percent. This compares with 46 percent in the United Kingdom and 23 percent in the United States; R. C. Ward, "The Role and Function of Science in the Modern Community," Public Administration, Vol. XXVII, No. 2 (June, 1968), pp. 104.

4. In 1960 the distribution of total research expenditure in Australia was approximately 20 percent in industry, 12 percent in universities, and 68 percent by government. Ibid., p. 103. This does not include the costs of operation of universities which are all government financed.

5. Derek J. De Solla Price, "Measuring the Size of Science," a paper delivered to the Israel Academy of Science and Humanities (February, 1969).

research expenditure as a percentage of GNP was lower than most of the countries in this group.[6]

The state of Australian industrial development is another important consideration in understanding the environment in which the tracking stations operate. In recent years, the Australian economy has been growing rapidly, financed in large part by foreign capital.[7] British and American companies with Australian subsidiaries traditionally have dominated industry, but recently others, such as the Japanese, have entered the market.[8] For example, of the four contractors operating tracking stations over the past several years, only one was an entirely indigenous firm. This tradition of foreign ownership is important in understanding why industry has not participated very significantly in basic or applied research and, instead, depends largely on imported technology.[9] Parent companies generally have not developed products specifically for the Australian market because of its relatively small size and similarity to other markets. Subsidiaries usually are used as assembly, sales, and marketing facilities and, as a result, do not maintain laboratories in the country. The commitment to industrial research and

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6. Ward, op. cit., pp. 103. For example, Australia spent 0.6 percent of GNP, whereas the United States spent 2.7 percent, the Netherlands 1.5 percent, and France 1.0 percent.

7. It is estimated that between 1956 and 1964 the percentage of foreign ownership in Australian manufacturing enterprises increased from 25.1 percent to 29.8 percent and is likely to continue increasing. See G. G. Moffatt, "The Foreign Ownership and Balance-of-Payments Effects of Direct Investment from Abroad," Australian Economic Papers, Vol. 6, No. 8 (June, 1967) pp. 1-24.

8. Caiden, op. cit., p. 8.

9. S. Encel, "Science and Government Policy IV - Australia," Public Administration (Sydney), Vol XXVII, No. 2 (June, 1968), p. 174.

development is thus limited and has an important effect on the question of technology transfer.[10]

Australia's international relationships are also important to consider. Australians, almost universally, see themselves involved in a partnership with the United States in matters of basic foreign policy. In addition, on the social level there seems to be a growing affinity towards the United States, although the strong influence of their predominately British heritage continues.[11] The extent of the social penetration is evidenced by the adoption of a significant number of American television programs, movies, and other forms of entertainment.[12]

In the area of space research, CSIRO and the universities have been active in the fields of radio and optical astronomy for many years. Space exploration other than the tracking involvement has focused on activities at the Woomera Range where the Australians have specialized in providing facilities and staff for the British and the European Launch Development Organization (ELDO). Australia has orbited her own scientific

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10. This, of course, is a generalization. ICIANZ and BHP have had laboratories for several years. Ibid., p. 188. In mid-1969, IBM (Australia), Limited announced the opening of the Australian System Development Institute. Financial Review (Sydney), May 13, 1969.

11. A former Minister of Defense and Supply has said recently that having large numbers of Americans in Australia emphasized the many similarities between the peoples of the two countries, not only individually but in a common heritage and past history of development. Interview with the Honorable Allan Fairhall, Minister for Defense (July 17, 1969).

12. For example, in television at least 50 percent of the programing must be of Australian content. However, of the imported content, about 75 percent is from the United States versus 20 percent from the United Kingdom. Personal letter from M. I. Homewood dated August 27, 1970.

satellite using a U.S. rocket, but a systematic program for space research has not yet been developed.[13] Indeed, in some respects the policy that does exist is negative.[14] There are a number of U.S. Department of Defense activities in this area, but they are generally United States planned and implemented.

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13. NASA put its Worldwide Tracking & Data Acquisition Network at Australia's disposal for this satellite. See "Australia to Send Up Own Satellite," Melbourne Age (May 19, 1967).

14. An example of this was reported by one space scientist who indicated that the only way he can place experiments on joint British and Australian rockets is to apply as a Britisher because the Australian government will not fund independent scientific experiments involving cooperative arrangements with other countries.

THE DEVELOPMENT OF SPACE TRACKING IN AUSTRALIA

In order to understand the administrative and organizational issues of the tracking operation, it is necessary to trace Australia's involvement in space activities and the long term relationships that have developed with NASA.

During World War II, the United States and Australia developed working ties that were both extensive and mutually rewarding. Militarily, the United States contributed significantly to the defense of Australia, and much of the direction of the war in the Pacific came from her shores. After the conclusion of hostilities the British role in the area diminished, and the defense relationships with the United States continued to expand, culminating today into what is almost universally viewed as "The Alliance." From these experiences a reservoir of mutual feeling and interest developed which virtually assured acceptance of the U.S. request to locate tracking facilities in Australia. Likewise, the confidence of Americans in the capabilities of Australians was such that the operation of the stations by them did not raise serious concern.[1]

One of the important reasons this capability existed was due to the development and operation of the Woomera rocket range. After World War II, Australia decided to participate in the newly emerging fields of missile

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1. When the contracts for operating the worldwide tracking system were first proposed, the initial NASA approach was to call tenders for operation of the network, including Australian stations, but NASA finally agreed to meet Australia's wish for Australian operation. Personal letter from M. I. Homewood dated August 27, 1970.

testing, radar, and communications technology. With British financial support she developed a test range using her unique resources of large areas of uninhibited territory, providing Britain with a much needed testing site.[2] Thus, they were able to develop competence in the field to an extent that was significantly beyond their own economic capability to finance. As a result, several important things occurred which were to influence the introduction of spacecraft tracking into Australia. In the first place, Australia developed a reputation in the West for having competence in range operation and tracking. Australian range personnel became acquainted with their U.S. counterparts, many of whom eventually became responsible for establishing the U.S. tracking system. Secondly, the Australian government, and the Department of Supply (DOS), in particular, established itself as the maintenance and operations agent for another government.[3] This predated the first NASA involvement by a full ten years and colored the way in which Australia viewed the relationships to be

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2. Interview with John Knott, Director General, Posts and Telegraphs, and former Secretary to the Department of Supply (July 7, 1969).

3. Admittedly this was not an arms-length arrangement because of close Commonwealth ties. The Weapons Research Establishment which operates the Woomera Range is itself a joint projects activity with the United Kingdom. Half of the expenses of Trials Wing of WRE are paid for by the English, and many British technicians, engineers, and administrators have been stationed in Australia to perform a large part of the British-oriented activities.

4. The Minitrack, which utilizes radio interferometers to do this, eventually became part of the more sophisticated STADAN system. The Baker-Nunn system, which optically locates satellites, continues its independent existence and is operated for NASA by the Smithsonian Institution. For a layman's explanation of the ways the various tracking systems function, see William R. Corliss, Spacecraft Tracking (Washington, D.C.: National Aeronautics and Space Administration, October, 1968).

established with the United States when requests were made for the construction of tracking stations.

The International Geophysical Year (IGY, 1957-58) marks the beginning of the U.S. - Australian cooperation in tracking and involved the placing of a Minitrack facility and Baker-Nunn optical tracking camera at Woomera.[4] The Minitrack facility was installed by the Naval Research Laboratory as part of the Project Vanguard Program and the Baker-Nunn camera by the Smithsonian Institution as a part of its attempt to record the movement of space satellites around the earth. From the beginning, these programs were cooperatively executed, and a basic pattern was established having program direction and tracking equipment coming from the United States with administrative and operational management provided by Australia. The basic arrangement persists today and bears a resemblence to the original working relationships established with the British. An important corollary to these events is that both the Smithsonian program and the Vanguard Tracking Program increased the technical intercourse between the two countries.[5] This meant that, when it was decided to have stations in the Southern Hemisphere, Australia was quickly chosen as the country in which stations might be most profitably located. Prior involvement, geographic location, political stability, and cultural affinity all played an important part in making the decision.

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5. In the case of NASA's absorption of Minitrack, this included both men and material. Many of the former Naval Research staff are now with NASA in senior executive positions.

The relationship that developed between the Department of Supply and NASA, after the latter came into being, was conditioned by the pressure to establish working agreements for a worldwide tracking system in a minimum amount of time. The primary reason for this was the need to establish stations for the Mercury network on an east/west axis throughout the world.[6] Australia was essential to the program because of its geographic position halfway around the world from Cape Canaveral and directly under the orbit path of vehicles launched from there. It was estimated at the time that such a Mercury station would improve, by a magnitude of ten, data on re-entry trajectories.[7] This was a crucial factor in the early manned-flight program. As a result of these time pressures, negotiations were rapidly concluded, agreement between the two technical agencies taking place before, but subject to, the conclusion of diplomatic negotiations between the two countries. The sequence of events was important because it emphasized technical requirements over political considerations and provided impetus to the practice of focusing on operations and performance as opposed to diplomatic negotiations.[8] The pattern of letting the technical people develop the operating relationships with the politicians ratifying them in the form of broad, flexible

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6. Interview with Edmond C. Buckley, former Associate Administrator for Tracking and Data Acquisition, NASA (February 28, 1969).

7. See NASA Office of Tracking & Data Acquisition, Memoranda to the Files by J. K. Sterrett, Spaceflight Operations, Subject: "Need for Australian Tracking Stations and Project Mercury" (September 23, 1959).

8. However, today's method of negotiating new agreements follows a more traditional pattern. In a personal letter from an Australian External Affairs Officer, dated September 28, 1970, he says, "...current practice is that government-to-government agreement on a project is required before work on a project may be commenced. (This procedure, of course, does not preclude preliminary technical discussions being carried on at the same time as the terms of the agreement are being negotiated.)"

agreements remains a characteristic of present day relationships. As a result, it tends to encourage the systemic feature of the arrangement as opposed to government-to-government relationships.[9]

In this regard, the immediate posting of a NASA representative to Australia was important. One of the first things agreed to by the Department of Supply and NASA was to have a senior NASA executive physically located in Australia.[10] His responsibilities were, and continue to be, to provide liaison for NASA-OTDA with the Department of Supply, particularly in matter of policy, administration, finances, public information, and other NASA-related activities. He is responsible for maintaining liaison with the United States Embassy, although his primary concern is with day-to-day relationships with the Department of Supply. Thus, the U.S. Mission in Australia, while informed about NASA activities, spends relatively little

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9. The idea that engineer-to-engineer relationships make the system work and that it is the administrators and politicians who cause difficulties is at least one the senior people in the system support. For example, a senior executive in the American Projects Branch, Department of Supply, suggested that the system works well in Australia in part because the politicians stay out of operations. A senior NASA administrator indicated that if it were up to him, he would never locate a station near a capital which housed a U.S. embassy, because although the diplomats mean well, they generate delays and problems with the host government due to their awareness of the presence of the stations. However, as indicated in footnote eight, the U.S. Embassy in Australia did not feel they were over-involved, due in large measure to the activities of the NASA Senior Scientific Representative.

10. See National Aeronautics and Space Administration, "A Study of NASA's Authority and Responsibilities for Establishing Tracking & Data Acquisition Stations in Australia, " Office of Tracking & Data Acquisition (February, 1967), pp. 15-1 to 16-3. The Jet Propulstion Laboratory and the Goddard Space Flight Center have also maintained representatives. Their function has been to focus on the technical operational problems of the network they represent.

direct time on them.[11] Although other U.S. government organizations have similar arrangements, what is important is that NASA's representative reinforces the preeminence of the two operating organizations involved in tracking. It is also important to note that this process has been further reinforced as communications within the tracking network improved. Real-time communication links are so developed that verbal communications between NASA in the United States and the Australian tracking establishment occurs uninhibited by international boundaries.

The initial agreement between the United States and Australia provided for five tracking sites.[12] In addition to the two already located at Woomera, a Project Mercury Station and a Deep Space Flight Station were to be installed. The fifth station was to be another Project Mercury site at Muchea, near Perth, in Western Australia. All of the stations were to be operated by the Department of Supply and, more specifically, by the Weapons Research Establishment (WRE), the organization within Supply responsible for Woomera's operation. Australia was to be the only country in the Mercury system where the electronic equipment would be installed by host

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11. The men most directly concerned with these activities--the chargè d'affaires, the political officer, and the economic officer--suggested in a interview that they spend less than one percent of their time on NASA matters because of the presence of the NASA Representative. Interviews with Messrs. Edward Cronk, James Martin, and Frank Mau (July 8, 1969). This minimun investment of embassy staff time is a long established pattern. Essentially the same relationship was in effect when the stations were first built in the country. Interview with Mr. Doyle Martin, former U.S. political officer, Australian Embassy (June 17, 1969).

12. Op. cit., "A Study of NASA's Authority and Responsibilities for Establishing Tracking & Data Acquisition Stations in Australia, " pp. 3-2 to 3-7.

country personnel.[13] This agreement marked the beginning of a tracking system within Australia with civil servants responsible for maintaining and operating an organization with geographically separated parts and staffed by several hundred employees including scientists, engineers, administrators, and support personnel. This contrasted with the rather small contingent that Australia provided at a single site as part of its contribution to the International Geophysical Year. Obviously, the problems of the government in operating what now came to be a "tracking business" were much more complex. An immediate issue that arose was the feasibility of using civil servants. In this respect, one of the more important questions was whether a large staff of government employees could be maintained, with all of their civil service employment protections, in a situation where stations might be abolished at short notice at the discretion of another government.

In spite of the difficulties of using government employees to operate stations, the Weapons Research Establishment attempted to do so for the first few years after the basic intergovernmental agreement was signed. Operational efficiency on all the stations was always very high, but because of such difficulties such as the length of time required to recruit into the public service, the stations were plagued by a shortage of staff.[14]

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13. R. M. Goetchius, "A Global Communication and Tracking Network for NASA - Project Mercury" in Fremont E. Kast and James E. Rosenzweig (eds.), Science, Technology and Management (New York: McGraw Hill Book Co., 1963), pp. 276.

14. Interview with Ian Homewood, Assistant Secretary, Projects Branch, Department of Supply (June 23, 1969).

During the early 1960's, even as these original stations became operable, NASA's increasing needs led it to request additional tracking sites in Australia. This culminated in agreements, signed in 1963 and 1965, for new stations to be located at Carnarvon (Western Australia), Darwin (Northern Territory), and several to be located in the Australian Capital Territory.[15] In the meantime, with the completion of Project Mercury, its stations were closed. The increasing size of the tracking operation, with a projected staff of approximately eight hundred people, made continued operation of them by public servants extremely difficult. As complexity increased, the response of the Department of Supply and the Weapons Research Establishment was to form, in 1963, the American Projects Division, a projectized group within WRE to provide direct management and operations of the system. Prior to this, operations had been directed through the functional branches of what is essentially a scientific and technical research organization. This was not suited to the specialized operation which the tracking enterprise had become, and the new Division was formed with a certain amount of urging from NASA, whose own tracking organization is projectized. However, while this new arrangement provided the structure in which a new administrative emphasis could be placed on tracking, it did not address the fundamental question of staffing. This was finally resolved when the decision was made to move to private contractors for maintenance and operation of the stations and to rely on a small cadre of public servants to provide policy, technical, and administrative direction.

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15. Op. cit., "A Study of NASA's Authority and Responsibilities for Establishing Tracking & Data Acquisition Stations in Australia, " p. 3-9. The station at Darwin was not permanent and was only utilized to support a single program.

The movement to this mode of operation represented a melding of the several different interests of NASA and DOS, the most important being that, if work load requirements changed drastically, the Australian public service would not have to absorb a large body of specialized engineers and technicians. In addition, the Australian government, which is concerned with encouraging its own industry, saw it as a means of "spinning off" into the domestic environment, some of the technical and management knowledge acquired at the stations.[16]

The move to the contracting approach was not without precedent in the Department of Supply. During World War II, when the Department's responsibilities for military procurement significantly escalated, Australian industry successfully contracted to produce the arms, ammunition, clothing, etc., that the Department's factories had been unable to manufacture.[17] However, the American Projects Division was unique in the sense that, for the first time on a large scale, private industry was asked to provide a service to the government which did not produce goods, but rather met a personnel function of supplying technical expertise on a continuing basis.

The role of NASA in the evolution of this pattern of operation was not entirely a passive one. The NASA-operated tracking stations, both

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16. Interviews with M. S. Kirkpatrick, Deputy Director, Trials, WRE, (July 2, 1969); Honorable Allan Fairhall, op. cit.; Mr. John Knott, op. cit.

17. Interview with T. F. C. Lawrence, Deputy Secretary (Research and Engineering), Department of Supply (June 26, 1969).

domestically and internationally, had followed the same basic pattern from the time it had become responsible for the system. NASA had also wanted to avoid the problem of having a large cadre of civil servants operating stations, but unlike Australia, which perceived the move as a means to developing industrial expertise, NASA saw the use of private contractors as a means of bringing into government technical skills that were already vested in the private sector. As a result of the very successful relationship that NASA evolved with its private contractors, it strongly supported the adoption of this method of operation when the problem of staffing became acute in Australia.

The move to the use of contractors created new difficulties in the operations of the stations. It raised for the first time the issue of union-employer relationships. Australia's work force is highly organized, and employees of the contractors belong to several unions. Labor relations is governed by a system of compulsory arbitration which subjects almost all issues to legal adjudication. However, it is not uncommon for strikes to take place in spite of the system, and this caused a great deal of concern because of the operational reliability that the worldwide tracking system requires. A strike or threat of strike just before or during a mission would give a significant amount of leverage to a union seeking to win benefits for its members. Two things have happened to minimize the possibility of this kind of disruption. First, in 1965, the Metal Trades Employers Association, which is the representative of the private contractors, sought and received an arbitration award legally establishing space tracking as an industry, while separating the roles of the Department of Supply and the

private contractors from each other [18] and establishing the terms of employment for workers at the stations.[19] This provided a uniform basis for adjudicating the demands made by the many unions represented on the stations and legally, at least, separated what is a very blurred division of authority and responsiblity between the DOS representatives and the contractor's administrators.[20] However, this by itself does not explain the absence of major strikes, since the same types of awards exist in other industries characterized by labor strife.[21] Rather, a second factor seems to be more important. The staff at the stations have developed a high degree of loyalty to the NASA tracking system and to the high performance of individual stations in that system. There are a number of reasons for this phenomenon, not the least of which is a sense of international responsibility which has arisen among the Department of Supply, the private contractors, the unions, and the station employees. Historically, these loyalties have taken precedence over trade union concerns.

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18. DOS is considered to be the contracting agency with NASA and responsible for policy and direction at the stations, while the private contractors are contractors to DOS and are responsible for operation and maintenance of each station.

19. See Commonwealth Conciliation and Arbitration Commission, Australia, Award--Space Tracking Industry issued on February 26, 1966, No. B148-20465/66 and its modifications Nos. B2169-8934/67, B2266-8717/67, B3115-16449/68.

20. The awards that were made are looked upon as very favorable to the employees' interests by the employers' trade association. Interview with Mr. B. C. Hungerford, Chief Industrial Advocate, Metal Trades Employers Association (July 19, 1969).

21. There was, up until 1969, only one strike for one day during the history of the stations. It was reported that the employees did this at a time when their absence would not seriously affect operations. There is also a recorded case at one of the stations where union members refused to follow their leadership and go on strike because of its possible effect on a mission.

In addition to the growth that tracking station operations caused within the Department of Supply, there were parallel developments in other Australian public enterprises. The two organizations most directly affected were the Post-Master General's Department (PMG) and the Overseas Telecommunications Commission (OTC). Both of these organizations are responsible for communications in Australia, with the PMG having responsibility for internal messages and OTC for all overseas communications. Supporting the stations was a significant challenge to both organizations, as NASA required a degree of reliability in communications that had theretofore never existed in Australia.[22] As a result, new equipment and techniques had to be imported to sustain the tracking operation. For example, the open-line link between the station at Carnarvon and the city of Adelaide, which was one of the longest in the world, was supplemented by a Comsat earth relay station in order to insure the reliability required by this isolated station in Western Australia. This was the first Australian Comsat station, and it was specifically built to meet NASA requirements.

In addition to building new facilities, a continuing supportive relationship evolved between the two communications organizations, the DOS and NASA. During NASA-declared, critical periods (such as Apollo missions) special precautions are taken, and all available manpower is utilized to insure that the communications systems do not fail. One of the most important reasons for this (just as with the labor unions) is the perceived international responsibilities which supporting the tracking network places

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22. Knott, op. cit.

upon the organizations.[23] On the other hand, government organizations have benefited from NASA's support. Engineers from the Department of Civil Aviation and the Bureau of Meteorology have obtained a great deal of experience in systems engineering and have participated in staffing the Applications Technology Satellite Station at Cooby Creek. This has enabled them to gain knowledge of experiments of interest to their organizations in the fields of general communications, aircraft communications and navigation, and meteorology and data transmission.[24] Finally, the money that NASA has spent in Australia has contributed significantly to the revenues of the communications organization. For example, leased circuits, which in 1969 were the largest single revenue earner for the Overseas Telecommunications Commission, increased OTC's international services revenue from 4.9 percent in 1958-59 to 28 percent in 1967-68.[25] Of this amount, NASA now provides approximately 50 percent.

As the discussion above indicates, the growth of tracking stations in Australia evolved in three stages. The first began with a rather modest commitment made during the original International Geophysical Year program through 1960. The second was a stage of rapid growth, which extended between 1960 and 1965 and culminated in the basic patterns of operation which exist today. The dispersion of stations throughout Australia, the introduction of

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23. Interview with staff members of the Planning and Research plus the Works Divisions of the Post Master General's Department (July 7, 1969).

24. See Department of Supply, "Applications Technology Satellite (ATS) Station, Cooby Creek, Darling Downs, Queensland." Central Drawing Office, Maribyrnong, Australia (No Date), p. 6.

25. Australia, The Overseas Telecommunications Commission, Annual Report and Balance Sheet for Year Ended 31 March, 1968, pp. 5-8.

private contractors, the projectized, complex organization within the Department of Supply, and the large-scale commitment of other government services all occurred within this period. The third stage--the present one--might be termed the period of institutionalization. The U.S. and Australian commitments to each other seem firm; the size of the system seems to be established; and all involved seem to be concerned with perfecting existing relationships rather than developing new ones.[26] In considering these stages it is evident that the system evolved over time rather than being the result of a preconceived initial plan. It was reported, for example, that since the first decisions to allow the stations into Australia, the basic policy issues of their continued operation in the country have not been discussed at the political (cabinet) level of government, even though their size and complexity have changed materially.[27] As a result of this, and because of the uniqueness of the tracking operation, a highly pragmatic organizational arrangement has developed with loyalties that transcend national boundaries.

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26. Exceptions to this, as of 1969, were the planned closing of the ATS station at Cooby Creek and the addition of a new 210 foot dish at Tidbinbilla near Canberra, but these changes are within a basic system. Subsequent to this research being completed, NASA agreed to leave the mobile ATS station in Australia until mid-1970 for Australian authorities to pursue their own experiments with ATS I. By keeping the station, Australians hoped to give a major boost to the solution of domestic communications problems without Australia having to make a major capital investment in such a facility.

27 Fairhall, op. cit.

OPERATION OF THE TRACKING SYSTEM

As was indicated earlier, the initial placing of Australia's space activities at Woomera led to the Weapons Research Establishment's assuming operational responsibility for the NASA tracking stations. As the system became more complex, WRE developed organizational structures to adjust to greater complexity, with the movement to private contractors and the projectized approach being the two major examples. On the other hand, because of the civilian non-defense character of the tracking stations, some within the Australian defense bureaucracy questioned the rationale of WRE continuing responsibility for them.[1] This factor, coupled with a major geographic movement of tracking activity from Woomera to the Canberra area and the location of stations in other parts of the country, established the national non-defense character of the system and eventually, contributed to the removal of the America Projects Division from WRE to the Department of Supply in Canberra.[2]

After the move to Canberra, American Projects was made a branch of the Research and Development Division of DOS and continued its role as manager of the stations. In addition, it remained responsible (along with senior policy people in DOS) for representing NASA's interests throughout Australia and dealing with private contractors, the communications media, and other

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1. Kirkpatrick, op. cit.

2. Three of the stations in Australia are now located there as well as the major communications switching center for all of them.

government agencies.[3] In this role it is generally perceived by others as the agent of NASA and has been thought of at times as over-representing tracking interests. Undoubtedly, a great deal of its loyalty to NASA has resulted from the projectized approach which ties careers and promotion to satisfactorily meeting requirements of another government. Also, the fact that real-time communications are achieved and regularly used causes the operational managers to identify more closely with those who direct the system in the U.S.

The use of NASCOM also has system reinforcing effects on the attitudes of station personnel. The stations have to be responsive to the operational demands placed upon them by the individual system of which they are a part. This means that personnel can be in instant contact with each other and develop relationships and loyalties which would not necessarily occur without the communications system. This has led to the decentralization of organizational responsibility down to the individual station manager and his subordinates. American Projects Branch deals largely in overall operational policy, being concerned with how the Australian system (a geographic entity) works as opposed to individual stations which are primarily part of functional systems.[4]

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3. Some of the more prominent are the Prime Minister's Department, Treasury Department, Department of Public Works, Ministry of External Affairs, The Post Master General's Department, and Overseas Telecommunications Commission.

4. Having the NASCOM system does not insure that effective communications take place. One Australian station director indicated that in spite of NASCOM, the greatest problem in the tracking system was communication. He indicated that the periodic station director meetings help to some extent. The need for face to face communications in human intercourse has long been recognized by businessmen who still travel, in spite of the development of inexpensive communications.

The basic pattern of station operation is to have a small team from the Department of Supply, usually a station director, one or two deputies, and an administrative officer, responsible for the overall direction of the station. The actual operation of the station is left to a private contractor led by a senior company representative or an operations and maintenance manager.[5] Perhaps the most significant organizational question occurs in the area of leadership. Private contractors have the responsibility of operating the stations and their representatives see it as their charge to do so under the contract. Station directors see it as their responsibility to oversee the operation of the stations, to make general station policy, to insure that the contractors perform well, and to make sure the stations live up to their commitment to NASA. Invariably this leads to a number of gray areas in which either of the two men may be sensitive as to who exercises authority. A good example is the extent to and level at which the station director or his assistants can give orders to the employees of the contractor. This issue has recently been highlighted by the fact that the Department of Supply has begun to move to incentive fee contracts and the question of DOS decisions affecting the awarded fee has already been raised.[6] In a sense, the gray areas of station operation are

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5. The separation of functions between operations and management are not always as clear as this statement would make them seem. At the Carnarvon Tracking Station, the Deputy Station Director is also one of the two flight mission operators responsible for operating the station during manned flights. The other operator is an employee of the private contractors.

6. The use of incentive fee contracts for operation and maintenance of tracking stations was evolved by NASA to improve effectiveness. The decision to move to them in Australia was greatly influenced by the NASA experience.

but a reflection of the broader issues raised when private enterprise becomes responsible for providing services to meet a public function under the direction of public servants. In Australia, the way in which these issues are resolved will probably depend a great deal on the patterns that are finally established at the tracking stations.

Another interesting facet of operations at the Australian stations is the question of station loyalties. As was already indicated, strong ties to NASA projects and the tracking system have developed at the stations. Loyalties are often with the individual station first and the network second, although, in some cases, this order seems to be reversed. The Department of Supply and the contractors run very far behind in terms of employee identification. In addition to the role played by communications and the concept of international responsibility in causing this to occur, several other factors must be considered. Some of the differences in system versus station loyalty can be explained by the fact that different stations are part of different tracking networks within NASA. These subsystems have independent operation management, and their abilities to generate loyalty seem to differ. In those networks where the employees feel that they are able to play an important and respected role in the operations of the subsystem, there seems to be a high level of loyalty. In those in which decision-making is perceived as being centralized with little input allowed from individual stations, loyalties center on the station.

The tendency towards station loyalty in all networks is reinforced by a friendly competition among the NASA stations to achieve high performance.

Australians are particularly competitive in this regard and their stations consistently have been rated very high. The reason can be attributed to the "Australian National Character or Pride." While it is dangerous to deal in generalizations about any people and particularly, to ascribe reasons for these generalizations, in this case the phenomenon is so widespread that even the most casual observer would see it.[7] The feeling of obligation to Australia's international responsibilities is a manifestation of this factor as well as the extraordinary support given to the communications process by OTC and PMG employees during critical missions. This feeling of responsibility stems in part from the Australian need to make themselves known to the rest of the world. Being from a small nation in a remote part of the world, Australians have a strong desire to be recognized. There is a great emphasis on demonstrating technical competence to the rest of the world and the effort in tracking is one way of doing so. This character and the feeling of pride associated with it has led to a strong commitment to the individual stations and to concern for their effectiveness in the system.

Having the stations in Australia has contributed to the general interest in the space program, which in turn has reinforced the interest in the stations themselves. Every year thousands of people visit the tracking sites and the fact that the stations are open and run by Australians is certainly

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7. To discuss national character is, of course, not unknown. Alexis de Tocqueville's Democracy in America discussed the American character as early as the first half of the 19th century.

not lost on them.[8] The general public interest contributes to the prestige of an individual participating in the tracking enterprise which in turn leads to pride in the job.

There is a paradox in the discussion of loyalties. Although a great deal of it can be explained in terms of Australian pride, the majority of the technical people involved are not native born and, in a good many cases, are not citizens of the country. The reason for this is that Australian universities and technical colleges do not produce enough science, engineering, and technical graduates to meet the needs of the society. If the senior engineering and administrative staffs of the stations are considered, almost 80 percent were born elsewhere. Most of these people (New Australians) are originally from Great Britain and New Zealand. They immigrate or are recruited to Australia because of the opportunities for employment and are part of the net importation of scientists and technologists that is now taking place.[9] Many of them come directly to the tracking stations to work. Thus, whether they are working for private contractors or government is often less important to them than the fact that their work experience is at the stations and with the NASA controllers in the United States. This eases the problem of developing system loyalties.

The fact that many of the employees at the stations are from Great Britain and that most others are from the large Australian cities has led to

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8. It was reported that even at Carnarvon, a very remote site in Western Australia, between six and seven thousand people a year visit the station. In the Canberra areas, the numbers are significantly larger even though the stations are purposely located in remote areas. Interview with Ted Cohran, Director of the Bureau of Tourism, Carnarvon, (July 1, 1969).

9. Encel, op. cit., p. 172.

special morale problems at the more remote tracking sites of Carnarvon and Woomera which are away from urban centers. Because of their isolation, the Department of Supply and NASA have gone to considerable lengths and expense in providing adequate housing and other incentives for their staff. Recruiting for these stations is difficult; one of the important reasons for locating the newer stations in the Canberra area was the relative ease of encouraging people to live there.

WHO BENEFITS?

In the previous chapters, a history of the Australian tracking system and a summary of some key operational characteristics of currently operating stations have been presented. From this review, it is apparent that benefits accrue to both the United States and Australia through the existing arrangements. In this chapter, the question of the advantages and disadvantages will be more systematically evaluated. There is a two-fold purpose in doing this. In the first place, it is worthwhile considering the interrelationships between operational success and the advantaging of various groups in a society. On this basis alone it would be valuable to consider benefits, because, in this case, the issues have bilateral, national, and sectoral ramifications. Secondly, the concluding section of this paper will attempt to identify future operating conditions, and to do this, it will be important not only to analyze what has happened in the past but also to consider how the benefit situation might be modified.

In discussing the advantages of having the stations, it should be noted that the incremental process by which the operation developed in Australia meant that, at different times, different conceptions of its importance were prevalent. Therefore, there is no easy analysis which can be made, listing advantages and disadvantages and then measuring them against existing conditions. Rather, consideration must be given to the time frame involved. It is entirely conceivable that benefits sought and discarded as unreachable may some day be relevant. Likewise, today's disadvantages may be reversed in the future.

The most important feature in the relationships between the Americans and the Australians is that they are in a situation where everyone seems to win or, at least, not lose by having the stations.[1] The benefits to Australia involve a wide range of considerations. Politics is one of the most important of these. The increased intercourse between the nations adds support to the Alliance, although these activities are far from being crucial to it. There are other more critical relationships which are so overriding that the absence of the tracking stations would have little impact, although their removal without cause by one or the other of the parties would undoubtedly affect the relationship. This would be unlikely to occur without some other more serious issue being at stake.[2] Suffice it to say that cooperative tracking relationships are a small, but well publicized, part of the entente. These international ramifications are quite obvious to both the American and Australian governments, and there is almost universal agreement about them.

There are, however, more subtle domestic ramifications which are less tangible or apparent. Australia does not have the same acceptance of the role played by modern government in the promotion of basic scientific and technological research that other countries, notably the United States, have. CSIRO, with certain important exceptions, is primarily involved in applied research for very specific ends. Accordingly, the idea of supporting

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1. In other words, they are in an N sum as opposed to a zero sum game, see W. H. Riker, The Theory of Political Coalitions (New Haven: Yale University Press, 1962), p. 300.

2. Interview with an External Affairs representative, Department of External Affairs (July 10, 1969).

research with no obvious payoff has not been widely accepted by the populace, and it is certainly not of great interest to the political leaders, who have considered such support unprofitable. The involvement with stations and the U.S. space program has contributed to the understanding of the "spin-off" potential of research programs which may seem esoteric to most Australians. The benefits of NASA's involvement in this regard are intangible and obviously not measurable. But the advantage is a real one, influencing senior leaders who are attempting to create a climate of acceptance for similar kinds of programs with the voters.[3]

Another benefit that has accrued to Australia lies in the area of science. There has always been an interest in the benefits which might be derived for her scientists from being able to use the equipment in the stations and, in fact, the stations have always been available to scientists on a non-interference basis as part of the cooperative agreement between the two countries. As early as the International Geophysical Year, WRE had arranged for ouside scientists and some of its own staff in the Woomera stations to collect data. However, because of the ad hoc nature of the situation, they never felt they derived as much from this as they might have, and when the American Projects Division was formed, a special research group was incorporated whose function was to systematically use the stations for research.[4] This group, although small, had done a good deal of research using stations in the United States as well as Australia.[5]

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3. Fairhall, op. cit.

4. Kirkpatrick, op. cit.

5. Interview with Dr. David Robertson and his staff, Space Research Group of WRE (July 2, 1969).

Outside of WRE's involvement, very few scientists have been able to utilize the stations. There are a number of reasons for this. In the first place, radio physics is the area where they would most likely be used, and there are alternatives, the CSIRO radio telescope located at Parkes, New South Wales, being the most prominent. This is a world-famous antenna on which much of the best work in the field is being done. In 1969, it was much larger than any NASA antenna in Australia and was used almost exclusively for scientific research. In addition, it has a reputation of being available to all qualified scientists in the country.[6] However, by itself, this does not explain why the NASA stations have not been used more often. There are other uses to which the stations could be put, and there is the need in many experiments to utilize several stations in Australia or around the world. Also, there is greater demand for time at Parkes than there is time available, and it is logical to think that there would be a spill-over onto the NASA stations. Finally, at least in the opinion of one of Australia's leading physicists, the research potential at the NASA stations is as great, if not greater than, that at the Parkes facility, because, while the CSIRO antenna is much larger, the equipment within the complex is in the "Model T" stage as compared with the tracking station electronics.[7] It is hard to imagine scientists not attempting to utilize the stations under these conditions.

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6. In addition to the CSIRO staff, there is an unwritten understanding that university scientists will have about 15 percent of the time.

7. Interview with Professor McCracken, Department of Physics, University of Adelaide (July 4, 1969). Dr. McCracken is now an employee with CSIRO.

There are other reasons why the NASA stations have not been more fully exploited. One is the precedence that NASA missions (which are extensive) must take over other activities. Some, like the Space Research group at WRE, have been able to work under these circumstances, but outsiders have not yet been able to develop techniques for doing so. Another very simple reason is cost. NASA has been willing to make the stations available to scientists, but they do require that the operating costs of the stations during extended experiments be paid for by the users.[8] While this is certainly a "bargain," the fact remains that Australian scientists generally do not have the resources available to pay for these operations. Obviously this seriously limits their ability to use the stations. The traditional behavior patterns of scientists, as well as the relationship between them and the government, is another important factor. Australian scientists as a group have not yet become academic entrepreneurs as have many of their counterparts in other countries, notably the United States, and as a result, have not mastered the techniques of recruiting government support for their research, nor have they learned the ins and outs of working with the government.[9]

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8. Essentially, NASA is offering its large capital investment in men and equipment and is willing to absorb depreciation costs. This is no small amount as NASA has millions invested in the stations.

9. Interviews with E. G. Bowen, Chief of the Division of Radio Physics, CSIRO (July 15, 1969); Professor McCracken, Department of Physics, Adelaide University; Professor Eric Rudd, Department of Economic Geology, Adelaide University. It is not meant to suggest here that all is well between the U.S. scientists and their government. But the problems that exist are not how to establish relationships with the government but rather how to manage them.

The fact that the stations are under the jurisdiction of the Department of Supply has not facilitated their use as Supply has not taken an active role in encouraging outsiders. Being a part of the defense establishment, Supply has a mandate to encourage defense research but none to support work of a purely civilian character. If Supply were actively to encourage such research, it would not be supported by the other defense ministries which would consider it improper.[10] As a result of this difficulty in supporting civilian research, the Department is not well known by scientists, and while probably they know that there are some opportunites at the stations, they are not clear how one goes about using them.[11]

In summary, while it cannot be said that science in Australia has benefited enormously, there has been a worthwhile payoff to the country from WRE's research. Government officials, as well as NASA executives, have reduced their initially high expectations for such activities because of the complex problems which surround this question today.

One area in which there has been continuing interest on the part of Australians has been the technical payoff from having the stations. This concern began with the early efforts at Woomera and continues today, although the approaches to maximizing the benefits have changed as operating conditions have been modified. The potential technical payoff, together with preservation of the Alliance, are seen as the two most important reasons for allowing tracking operations within the country.

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10. Interview with Mr. Arthur Wills, Director of Research and Development, Ministry of Defense (July 14, 1969).

11. McCracken, op. cit.

The effects of technology can be divided into two categories--first and second order. The first-order advantages can hardly be disputed although, paradoxically, some aspects of them are. These effects are the direct advantages that have developed from having the stations. They are the technical experience that a large number of residents of the country have gained, using "state of the art" equipment in communications, electronics, digital computers, etc. Without the stations, this is not likely to have occurred or, in some cases, to have been as extensive. Also, there has been a great deal of organizational experience in forms of large scale management that are unique to the Australian environment, and which probably would not have been attempted without the NASA relationship.

Another first-order effect has been the attraction from abroad of a large number of qualified engineers and technicians to operate the stations. One of Australia's prime goals since World War II has been to attract immigrants to its shores. Those, who are attracted to Australia because of opportunities at the stations, have the advantage of bringing with them highly desirable skills. It is because of this phenomenon that the only major argument raised against having the stations does not hold up under examination. This is the suggestion that the employment of large numbers of highly skilled personnel in the system robs Australia of a very scarce resource which could be better utilized in activities that bring more direct benefits to the country. This would be a very powerful argument if it were not for the fact that such a large number of people are attracted from other countries to work at the stations. Even those immigrants originally in other jobs who later moved into tracking activities make available additional skilled jobs to which others can be attracted.

From the direct experiences in working with the tracking system should come the second-order effects, or the "spin-offs," as they have been called. Many Australian officials originally felt that there should be a substantial benefit to other enterprises because such advanced technology would be operating within their country. However, most now agree that spin-off has not yet occurred to any measurable degree, and it is in this area that major modifications, in the form of bringing in private enterprise, have been made.[12] Perhaps the most important reason for this is the relatively stable employment of personnel within the tracking system. There are only a small number of people involved, and few of them have been attracted into other activities.[13] This factor is of crucial importance as it is now realized "...that the mechanism of technological transfer is one of agents, not agencies; of the movement of people among establishments, rather than the routing of information through communications systems."[14] There are a number of reasons why personnel turnover is not as high as it might have expected in view of the hardships of working at some of the stations and

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12. For example in interviews with Knott, op. cit., Wills, op. cit., Bowen, op. cit.

13. Interviews with Mr. Donald Gray, Station Director, Tidbinbilla Tracking Station (July 9, 1969); Mr. Dennis Willshire, Station Director, Orroral Valley Tracking Station (July 21, 1969); Mr. Colin Smith, Operations and Maintenance Manager, Carvarvon (June 30, 1969); Mr. Norval Scott, Assistant Managing Director, EMI Electronics Proprietary, Ltd. (July 17, 1969).

14. Tom Burns, "Models, Images and Myths," in William H. Gruber and Donald G. Marquis, Factors in the Transfer of Technology (Cambridge, Massachusetts: The MIT Press, 1969), p. 13

the high levels of skills that are developed by doing so.[15] Among the inducements which keep people on the stations are the relatively high wages and attractive benefits that are offered. The operations have always been seen as a unique activity requiring high quality work and flexible working hours, and as a result, wages and benefits have been set at a very attractive level relative to similar activities in Australia.[16]

In addition, the ability of outside industry to absorb personnel from the stations has been limited. The skills developed during employment at them are not easily transferred to individual firms. Most of the station technicians and engineers are over-qualified in the sense that their day-to-day activities do not require the level of skills that they are hired for; rather these skills are required for the diagnostic ability that is necessary to maintain the reliability of the stations, and these kinds of skills have not been easily transferred into the domestic electronics industry.[17] There is only one area where outside industry

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15. Some of the more isolated stations (for example, Carnarvon) have on the face of it, experienced a high turnover rate. However, the people who leave are mostly those who cannot accept the changed living standards. There is a strong corps of people who remain at the stations for a long period of time, and it is from these that the "spin-off" would come. Interview with Mr. Colin Smith, Operation and Maintenance Manager, Carnarvon Tracking Station (June 30, 1969).

16. See Commissioner Neil's statement on the uniqueness of the industry in the Space Tracking Industry Award B 1484-20465/66, op. cit., p. 10.

17. Interviews with Mr. R. D. Stewart, Manager of the Engineering Products Division, Amalgamated Wireless, Australasia Limited (July 16, 1969), and Mr. G. J. Donnan, General Manager Electronics Division, Hawker de Havilland, Australia (July 16, 1969).

seems currently to be able to compete with station employment and that is the rapidly expanding digital computer industry. As a result, some employees are now leaving the stations to work in this field.[18]

These difficulties which have been encountered in the spread of technical information from the stations were largely unanticipated. In fact, when the decision was made to use private contractors instead of civil servants to operate the stations, it was more palatable because it was assumed that it would significantly aid the "spin-off" process.[19] As a part of this decision, the Department of Supply attempted to maximize the potential "spin-off" by interesting the largest electronics firms in Australia in operating the stations. They reasoned that, by using as many firms as possible, competition would be stimulated and "spin-off" would be introduced widely into the electronics industry. As a result, Supply has encouraged four contractors to enter the field.[20] All are large corporations, and no one company operates more than two stations. Executives in these corporations all agree that one of the important reasons they went into the business was for the "spin-off" their firms could derive from it. They also agree that this has not taken place and offered as possible reasons some of the issues discussed above, particularly the difficulties

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18. Interview with Dennis Willshire, Station Director, Orroral Valley Tracking Station, July 21, 1969.

19. John Knott, op. cit.

20. After this research was completed, the Department of Supply reversed its policy, and the number of contractors has been reduced to two.

of integrating personnel from the stations into their parent companies.[21] Interestingly enough, they all agreed that they remained in the business out of a feeling of national loyalty or prestige or out of deference to the Department of Supply with which their firms had other contracts.[22] Profit, they said, was a minor factor, in that it was a relatively small, but an assured, amount.

Other reasons can be suggested to explain why there seems to have been very little benefit to industry from the tracking involvement. One undoubtably lies in the fact that virtually none of the electronics equipment used in the stations is manufactured locally. This inhibits interrelationships evolving between industry and the tracking operations which would encourage the utilization of technical knowledge derived from station experience. One model which provides a probabilistic explanation of the transfer of technical information into new uses suggests that the sequence of events within the organization of a potential recipient or user of existing technology must follow some pattern in which ideas, research, development, production, innovation, and diffusion are present.[23] This is a highly complex process and the probabilities of successful

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21. In addition to the two previously mentioned company executives, Mr. Norval Scott, Assistant Managing Director of EMI was interviewed on July 17, 1969, as well as Mr. D. E. Harbour, Marketing Director, Standard Telephone and Cable Proprietary Ltd. (ITT) on July 16, 1969. All four are responsible for the operations of their firms in the tracking field.

22. In this respect it is important to note that there was concern expressed among some that the Department of Supply does not give enough credit to its contractors and hoards the best of it for itself.

23. William H. Gruber and Donald G. Marquis, op. cit., p. 6.

transfer would seem to be significantly reduced if the space tracking industry, which is most likely to utilize innovations, is closed because equipment is provided from the United States.[24]

A more speculative reason why this "spin-off" is absent lies in the way the tracking industry is organized. The Department of Supply effort to maximize participation by the major elements in the electronics industry has led to a situation in which each of the four firms involved has only a small stake in the business. Central administrative organizations are not necessary to manage and coordinate activities and there is almost no movement of personnel between stations. Hence, loyalties for company employees, including management, lie within the station, little communication exists between the parent company and station, profits for firms are small, and what was to be an important industry has become a sideline for several large firms. Without a large enough base to be concerned with tracking as a major economic endeavor, companies have not been willing to invest resources to transfer technical information into new technical innovations. Rather, they have looked for direct transfer of experience from the stations to the electronics industry, and because of the specialized nature of the operation, this has not been forthcoming. In the few cases where efforts have been made to utilize the tracking talent, the efforts have had to be small and associated with one station.[25] The companies,

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24. It is not meant to suggest that the reason for using equipment of non-local manufacture is an arbitrary one. The requirement for system homogeneity dictates that all major equipment at stations be identical. However, this does reduce the probability that there will be a "spin-off" to Australian industry.

25. The most notable example of this in 1969 was at the Tidbinbilla tracking site where they were attempting to market systems engineering skills.

although they have the support of the Department of Supply and NASA, have to be particularly careful not to interfere with tracking and to be scrupulous about avoiding the use of government materials and equipment.[26] These kinds of local operations can never be much more than a sideline, and it would seem to be more probable for significant "spin-off" to take place if the companies involved had responsibilities for several stations, with central headquarters away from them. They would then have a larger labor pool, the ability to draw on staff from many sources at any given time, and the capability to use station employees away from the stations when an interesting possibility to utilize their special skills and knowledge occurs.

Two major conclusions can be drawn about the effects of the tracking station technology. It cannot be disputed that a large number of technologists have gained experience they would not have otherwise received, but this experience has largely remained on the stations with little dissemination throughout the rest of Australian industry. There has been, as suggested previously, technical benefits to the organizations which support the stations (DOS, OTC, and PMG). These have been advantages which the NASA presence has generated but which probably would have come about at some later date. One of the reasons that NASA was so important in this process was because it provided the economic base from which the communications organizations could utilize advanced equipment and techniques

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26. Interview with Mr. Robert Cudmore, Senior Company Representative, Tidbinbilla Tracking Station (July 9, 1969).

to improve service in Australia.[27]

The financial and economic impact on Australia is an important aspect of the cost-benefit equation. The one area in which there has been a national impact--communications--has just been mentioned. The advantages to Australia of NASA expenditures should not be underestimated because they have brought major improvements in the crucial area of domestic and international communications. However, in other respects, the economic impact, while welcomed, has not had a major effect on the national economy. Most government officials rate economic motivation very low on the scale of reasons why the stations are important to their country. In fact, during the IGY the cost of operating them was borne by Australia and it was not until the operations were greatly expanded that NASA began paying for most of the costs. Since then an annual contribution of $157,000 has been made towards the operation of the system in the spirit of international space cooperation. Since 1960, NASA has spent approximately $118,000,000 on the Australian stations. This is a respectable sum, particularly since much of it was in a needed foreign currency. However, this total is less than 0.1 percent of Australia's GNP during the same period of time, and its relative importance must be kept in perspective.[28]

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27. An intangible technical benefit to Australians which cannot be measured is the extent to which having tracking stations enables them to have access to NASA technical information of which they might otherwise be unaware. For example, NASA work on ATS, Tiros and ESSA satellites has provided information in communications and Meteorology, Astronaut photographs have been of assistance in mineral exploration, and Geodetic Satellites in mapping. Much of this information is public and available to all countries but an inside awareness of them undoubtably helps.

28. United Nations, Monthly Bulletin of Statistics, 1958-1967.

The economic impact, while it has not been national in scope, has had important effects on areas in which the stations are located. Perhaps the most dramatic changes were in the town of Carnarvon. This town, although old and established, is located in an isolated portion of the coast of Western Australia and was in a period of decline at the time the station was built. The major industry in the area had been whaling, but this was becoming unprofitable and was being phased out. The local population was less than 3,000 people. Since the station was installed, the population of the town has more than doubled. The local government budget has climbed from less than $A200,000 to about $A1,000,000 per annum, and tourism has significantly increased.[29] In addition to the impact of the 600 new people that are associated directly with the station, other supporting organizations and service people, most notably OTC's Comsat station, have moved in to support the tracking operation. This has not only brought an economic boom to the area but has also modified the social and cultural climate.[30]

The other stations have had a less obvious impact because they have not so significantly altered the local economy. However, their effect has not been unimportant. At Woomera, for example, a significant number of dwellings were constructed using NASA funds and, particularly today when the use of the Range seems to be declining, the NASA activities play an increasing role in sustaining it. In the Canberra area the 400-plus employees of the

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29. Interview with Mr. Wilson Tuckey, President of the Shire Council; Mr. Ted Cohran, Director of Tourism; and Mr. Roy Chippendale, independent trucking and taxi owner; Carnarvon, Western Australia (July 1, 1969). Other factors which have affected growth in the past few years are a significant increase in mineral development and in market gardening.

30. Buckley, op. cit.

tracking stations, their dependents, and the service people who support them contribute to the local economy, although, because of the size of the Australia Capital Territory, it cannot be said that there is a significant impact. New public roads have been constructed near Canberra using NASA funds, and at all of the stations funds were spent locally in capital construction that made a one-time contribution to the economy.

Thus, the economic benefit to Australia has not been major, but given the areas in which it has occurred, it has been helpful. The situation is somewhat analagous to the economic advantages to Australian industry; the income, although relatively small, is assured, and it brings a relatively high rate of return with a low capital investment.

One final entity affected by the tracking station activities is the Department of Supply itself. On the political level, being responsible for the operation is certainly not a disadvantage.[31] It adds size and money to the Department's operations, and the responsible Minister receives a good deal of publicity both domestically and internationally.[32] Within the Department itself, a number of public servants have made successful careers working as participants in the system and have received the benefits of international training and travel. This does not mean that the relationship with NASA is universally accepted. Within the ministry and other government departments, there are those who feel that Supply involvement with space tracking has detracted from its

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31. Interview with Senator The Honorable Ken Anderson, Minister for Supply (July 9, 1969).

32. The NASA 1969 annual expenditure in the DOS Budget was $A12,000,000 as compared with the expenditure of $A190,000,000 for the Department of Supply as a whole. Personal letter from M.I. Homewood dated August 17, 1970.

prime purpose of providing logistical support to the Armed Services of Australia. However, this has not been a majority view, and those who would press this issue have not had the power to do so.

The discussions so far have focused on the advantages and relative lack of disadvantages to Australia of having the stations. What, however, is the picture for NASA and the United States? The technical advantage of locating the stations in a stable, supportive environment has already been alluded to. Another important consideration is the contribution these activities make to the overall U.S. image within the country. The publicity the stations receive is greatly in excess of the financial resources that are committed to them. The impact of the peaceful civilian image of the space program run in partnership with the United States should not be underestimated, although its effect on the political equation cannot be precisely measured. This effect is important today because many of the activities of the U.S. Department of Defense in Australia have come under serious attack, particularly in regard to the question of partnership versus dominance. The NASA activities certainly contribute to the advantage of the United States in terms of the overall view of U.S. involvement within the country.

There are also more direct advantages to NASA from having the Australian Tracking organization as a part of its system. It is a very effective, competent organization which is better able to deal with the operations within its own country than an American organization could be.[33] In addition,

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33. The Australians follow a policy of keeping high-level personnel at the stations as opposed to keeping the engineers at headquarters and technicians on the stations which is the more usual NASA pattern. This has meant that the staffs at the stations are particularly well qualified. Interview with John F. South, former Goddard Space Flight Center Representative in Australia, (February 20, 1969).

this is done at a cost to NASA that is particularly favorable if the alternative of having to run the stations themselves is considered. Labor costs in Australia are significantly less than those in the United States for similar kinds of occupations, and not only has NASA been able to capitalize on this differential, but it has been saved the expense and trouble of having to support a large contingent of American families abroad. This would be not only expensive but much more difficult to administer.

Australia's small but constant contribution to the cost of operations, the free use of land (in all but one case) and the large commitment of manpower contribute to the international flavor of the tracking network. Thus, while it is really a U.S. national system, NASA is able to point to the international participation of others in it. This may become even more important in the future as domestic attitudes towards the space program in the United States seem to indicate a greater emphasis on its international cooperative aspects. This question will be discussed further in the final section of the paper.

It should also be noted that the Australian operation of the stations has drawbacks as well as advantages. In dealing with another country it is inevitable that there will be differences in methods and procedures of doing things, in working habits, and even in interpretation of language.[34] In the case of Australia, because of the close cultural affinity, the differences have been slight and the adjustments in behavior that NASA has had to make to accommodate them are minimal compared to the great benefit derived from the relationship.

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34. For example, in December, 1959, when the NASA administrators arrived in Australia to negotiate tracking agreements, they discovered that this was the traditional period for taking vacations, and it would be very difficult to find anyone who wanted to stay and negotiate. Buckley, op. cit.

ENVIRONMENTAL POSSIBILISM[1]

All things considered, the future of tracking operations in Australia seems to be bright. The advantages to both countries are so great that it is unlikely either would want to alter the basic arrangements.[2] However, it can be said with some certainty that actual operating patterns in the future will be different than those recognized today. There are several factors which will cause this, many of them involving issues that are much broader than space tracking itself. Two of the more important ones concern the future role of NASA and the national development of Australia.

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1. The concept of environmental possibilism is concerned with what is likely in the future, given future environing factors, such as changes in the social and technological environment which may affect tracking operations and is not meant to imply prophetic knowledge on the part of the author. In this sense "...prediction is best concerned with the future state of milieu within which decisions have to be made." -- See Bruce M. Russett, "The Ecology of Future International Politics" in James N. Rosenau, (ed.), International Politics and Foreign Policy (New York: The Free Press, 1969), p. 94.

2. It could be argued that the Australian view of national interest is likely to be such an important environing factor that the continued maintenance of tracking stations is assured for NASA. Indeed, this was suggested by an important Minister of the Government in a recent interview. Any analysis of environmental possibilism must consider this as a most significant factor. However, equally persuasive is the recent statement of two students of international relations in discussing the attitudes of people towards the future. They said, "Nearly everyone pays lip service to the idea that we live in an era of change and transformation. But one does not always find this awareness reflected in analytical viewpoints and models. On the contrary, we sense a tacit presupposition in much of the literature, both theoretical and substantive, that major innovations, discontinuities, and upheavals are simply facts of recent history; that the most disruptive changes have already occurred; and that environing conditions in the future are unlikely to differ radically from those to which we already are accustomed. All this despite indications of many kinds to the contrary." See Harold and Margaret Sprout, An Ecological Paradigm for the Study of International Politics, Center of International Studies, Princeton University (March, 1968), pp. 5-6.

With the completion of the Apollo program, it is already evident that NASA will undergo significant changes, both technical and directional. This will cause modifications of the level of funding and perhaps the requirements for space tracking. In the meantime, as far as Australia is concerned, the most important factor is the rapid political, social, and economic change which is already taking place in that country. Together with the changes at NASA, these events are likely to induce different perspectives of the tracking relationships on the part of all concerned. The series of events which will directly impinge upon the tracking operations center around four major themes: maturing of relationships between the two operating organizations and their administrative environment, technical changes affecting the characteristics of the stations, changes in benefit patterns, and the international and economic climate in which the tracking system will operate.

In turning to the organizational environment, it is already evident in Australia that the Department of Supply has undergone many changes. Both it and NASA were in different stages of organizational maturity during the evolution of the present tracking network. Supply is an old-line organization with well-established practices. The administrative responses it made when the tracking stations were set up were those which could be expected from such a mature organization faced with a new responsibility. First, it attempted to use existing procedures within the Department (e.g., the functional approach utilized by WRE). Later, as the system grew and became nationwide in scope, the Department was forced to change its usual methods of operation (hence the move to private contractors and the creation of the American Projects Division). It did this not by making any basic

changes, but by modifying existing structure. Later, it was recognized that the rationale of having the Division a part of WRE (whose interests were localized) was no longer logical, particularly since the focus of the effort had been moved out of Woomera. The Division was then incorporated as a part of the Central Headquarters staff and moved to Canberra where it exists as the only fully projectized Branch in the Department. The Department has shown over the past decade a willingness to modify its structure to accomodate the needs of NASA; it has moved incrementally towards an operational pattern that closely resembles the NASA tracking organization. Thus, a new task has introduced a need for structural experimentation in what is otherwise a traditional bureaucracy. The approaches to this experimentation were conservative because there was an existing base to build upon and change. If it had not existed, it is probable that the operation would have reached its present form more rapidly but with less concern for its operating environment. Since several issues remain to be resolved, such as the use of incentive contracts, it is likely that the American Projects Branch will continue to make changes in its operational patterns and, given the tradition of experimentation, it is possible that additional structural changes may be made to adapt to the new environment.

NASA, although it evolved in the same time frame, used a different pattern of operating techniques. A major reason for this, in addition to a different management tradition, was the stage of development of NASA when the tracking system was built. The construction of the tracking network was concomitant with the birth and early development of NASA as an organization. While both NASA, in general, and the networks, in particular, absorbed existing entities, essentially new organizations were born. This, coupled with the

need for the rapid construction of the Manned and Deep Space Networks and expansion of existing stations, forced the new tracking organization to set policy for operation of the system in a pragmatic manner. Since there were no firmly established procedures, decisions could be made in such a way that the peculiarities of each situation in which NASA sought to operate could be accounted for. This was certainly the case in Australia where previous IGY arrangements were expanded to provide a base for NASA activities.

The way in which the relationships between these two organizations evolved is important because of the effect it may have on their patterns of operation in the future. The most conspicuous feature of the relationship is its highly personalized nature. This is particularly important now, because many of the senior individuals who played a leading part in the process are retiring or are moving up into other activities in the public service. As a result, the relationships between the new administrators of the system, who do not know each other as well, are likely to become more formalized. Indeed, this seems to be already happening in the administrative areas.[3] It is occurring in a period when NASA, with a new leadership coming to the fore, must decide whether to institutionalize the methods of the previous leadership (e.g., flexibility, variety of operating styles) or the solutions they offered (e.g., the particular operating arrangements for stations). If the former is chosen, and particularly if Supply continues

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3. Interview with Mr. Alan Sinclair, Principal Executive Officer, American Projects Branch (June 23, 1969); and Mr. Ray Lloyd, Executive Officer, Finance and Logistics, American Projects Branch (June 26, 1969).

to experiment, it is more than likely that a continuing high degree of understanding will exist between NASA and Supply. If the latter path is followed and the situational variables within Australia change, the potential for divergence is increased.

In the context of this changing organizational environment, a series of issues should be examined. One of the more immediate of these is the changing administrative climate in Australia for U.S. projects. This is caused by expanding U.S. Defense Department activities within the country which are leading to an increased effort by all government Ministries to systematize relations with U.S. government agencies. Thus, the process of reaching policy agreements, which used to be relatively simple, is now becoming more complex, requiring different tactics on the part of both NASA and DOS to conclude them, so much so, that it now seems to take the approval of virtually the entire Australian Government to ratify an agreement.[4] In addition, when the initial agreements were negotiated, the primary goal was speed, and as a result, they were not written as "tightly" as the Australians feel they should have been and did not represent any basic departures from those concluded for the International Geophysical Year.[5] An excellent example of this change is the renewal of the basic operating agreement

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4. Interview with Mr. Ian Homewood, Assistant Secretary (Projects), Department of Supply (June 23, 1969). However, in his personal letter of August 27, 1970, Mr. Homewood indicates that "...although about half the Australian Government Departments have some input to the NASA Umbrella Agreement (most rather isolated), it does not involve virtually the entire Australian Government."

5. Interview with Mr. Desmond O'Connor, First Assistant Secretary and Mr. Bernie Long, Director, Agreements and Costing, Finance and Management Services Division, DOS (June 27, 1969). Mr. O'Connor is now Deputy Secretary (Management and Supply), DOS.

between the two countries which occurred during the Summer of 1969 and took much longer to conclude than either organization envisioned.

The question of automation is another that needs to be considered. It is not a problem unique to Australia but is particularly important in that country because of the commitment of a very high calibre of personnel in the stations. The basic issue is boredom, generated by equipment modulization and the increasing use of stations as relay devices for information to project control headquarters. The relay problem was evident in the stations from the earliest days of their existence.[6] A conscious attempt has been made to reverse the flow of information back to the stations with varying degrees of success depending on the network being considered.[7] However, as technical communication capabilities have improved, e.g., the abilities of computers at the stations to talk with computers at project control headquarters, a tendency has developed to give the stations less actual operational, and more maintenance responsibility. This, coupled with the increased number and complexity of NASA missions and their more esoteric nature, particularly on the STADAN network, has made the reverse information flow more difficult and has decreased the feeling of involvement. If the difficulties ended here, the problem would be much less complex. However, together with the emphasis on maintenance has come the movement to modulization. This is a process made

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6. Interview with Dr. Eberhardt Rechtin, former Assistant Laboratory Director for Tracking and Data Acquisition at the Jet Propulsion Laboratory, Pasadena (March 6, 1969).

7. For example, a worldwide NASA information network has been established. Also, NASA executives visit the stations periodically to learn about problems and new ideas.

possible by technical advances which enable component parts to be arranged in compact autonomous groupings. In the case of equipment failure, a technician or engineer does not have to isolate the problem and repair it. Instead, he only has to locate the module in which it has occurred, remove it and substitute another in its place. The defective module is then repaired on site or sent to a repair depot for disposition. While the replacement of modules is not the only activity at the stations, there is an unmistakable trend towards it, and one of the organizational ramifications is the reduction of the feeling of involvement by the employees. One of the obvious answers to this problem, particularly for Australia, is to downgrade the type of personnel hired and change the kinds of skills that are required.[8] This is a limited solution, however, since the diagnostic talents required of technical people are found only in highly trained individuals.

Another factor which is important in understanding this question is the continuing attractiveness of working with the equipment. If, as is suggested, one of the important attractions drawing personnel to the stations is the "state-of-the-art" equipment,[9] then, as the use of such equipment becomes more routine, and as working in the "space business" loses some of its excitement, it is going to become more difficult to attract the proper people to the station despite the high salaries. In the past, recruitment

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8. This is already occurring at the STADAN stations where the problem is most apparent. However, this is a problem that is not peculiar to them as it was suggested as an important problem by management personnel at station in all three networks.

9. "State-of-the-art" equipment is generally considered to be that equipment which embodies most current refinements of particular technologies.

has generally brought highly motivated as well as highly qualified people. This is particularly important because of the commitment to the work that is required. If the new operators, technicians, and engineers do not bring such commitment with them, a stronger emphasis will have to be placed upon developing station and network loyalties in order to continue the high level of efficiency.

This issue might be resolved by changes directed toward creating a space tracking industry. If some way could be found to reduce the number of contractors operating stations and if the economies of scale could be brought into play so that effort could be spent on broadening the skills developed by tracking work, it is possible that the same type of people would continue to be associated with the effort, and the small scale attempts at individual stations to utilize existing talent and to avoid boredom could be realized on a broader level.[10]

The development of a space tracking industry has, of course, greater implications than the problem of boredom. The concern for "spin-off" beyond first order effects is important and cannot be accomplished without some changes in the existing relationships between DOS, NASA, and the industry. A strong industry would have the effect of reducing station loyalty as movement to other stations would probably increase. Also, a consolidated industry would have greater leverage and a stake within the tracking enterprise.

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10. This possibility does not necessarily mean that the number of contractors involved needs to be reduced. It might be feasible, by utilizing some pooling of individual interests, to create one or two joint operating companies on the basis of making a contribution to the national interest.

This could alter the strong position of station directors vis-a-vis the individual contractors at each station and might result in the need for greater acknowledgement being given to the industry.

A question which probably will be reopened in the near future is the utilization of the stations by scientists. The stations are becoming busier as more space missions are undertaken and even with the best of intentions, the possibilities of using them are going to be reduced. On the other hand, the well publicized installation of a new 210-foot antenna which, at least, rivals Parkes' in size and performance, will make their use particularly attractive. Increased requests for time on the antenna will not be limited solely to Australian scientists. If the small amount of time that can be offered is given largely to Americans, the problem will be compounded. Assuming that the Australian Academy of Sciences gains more influence and that the university and government scientists become better organized in the future, the utilization of the NASA stations is likely to become a much more important factor.

A final issue is that of Australian participation in the system activities of the network. This could be particularly important if NASA moves towards an increased emphasis in international cooperation for all its programs. In a country like Australia, which has a cadre of well qualified personnel, there is bound to be a desire for participation in the overall activities of the system, particularly because such a conscious effort is attempted to make all the participants feel an equal part of it. Indeed, since Australians consider themselves to be at least technically equal to many of the NASA staff, some sort of systematic program for participation

could have very positive advantages for the tracking system as a whole.[11] In the first place, the not inconsiderable talents of Australian engineers could be utilized. In addition, a greater understanding within Australia for the problems of operating a world-wide tracking network could be generated, the feeling of equal cooperation and participation would be reinforced, and the development of system loyalties enhanced. It would also act as a factor in reducing boredom by providing the possibility of greater system participation and would assist in reducing the impersonality of the system as the original employees leave it.

While issues such as those discussed above are likely to affect space tracking directly, more basic underlying concerns also are going to have a continuing impact. The most obvious area is that of international politics. Changes in commitments by both governments in the not too distant future are likely, largely because of events in South East Asia. This could mean a rather sharp change in other U.S. government activities within the country and could affect the movement to government-wide reviews of tracking that now seems to be taking place. In the long run, however, the growing cultural affinity is probably more important than the vagaries of any momentary political interest. It is probable that this underlying factor will ensure continued favorable treatment for NASA, particularly since its activities have been effectively isolated from U.S. military programs.

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11. This has occurred occasionally, and in 1969, there was at least one Australian working at both JPL and another at Goddard, but it is not done systematically. Other activities which do occur, that both encourage and support this tendency, are the continued training of Australians in NASA schools and the utilization of Australian teams to take back and assemble tracking stations from the United States to Australia.

Perhaps the most important influence on the tracking enterprise in the long run will be Australia's movement into accelerated economic growth. NASA's expenditures on crucial economic and social development capital played an important and timely role, particularly in the area of communications. At this point in time, they still are important, but anyone who has visited Australia recently can sense the concentrated movement to mass exploration and utilization of Australia's natural resources. These activities are likely to generate growth that will make the NASA contribution relatively smaller. In addition, a growing commitment to national development is likely to alter the perceptions of economic and technical benefits that can be derived from the stations. In particular, if immigration, the universities, and technical colleges cannot supply enough highly trained personnel, there will be increased incentive, both financial and professional, for technical people to move on to other activities. The extent to which economic changes such as these will affect space tracking is problematic, but it is important that they be recognized and action taken at the appropriate time.