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THE ROLE OF THE REGIONAL DISSEMINATION CENTERS IN NASA'S TECHNOLOGY UTILIZATION PROGRAM

by John Geise

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16. Abstract

The objectives, operations, and accomplishments of NASA's Regional Dissemination Centers for technology transfer are discussed, with full documentation, and special attention to innovative procedures each has devised to bring the benefits of new aerospace technology to both private and public sectors of the national economy. NASA's entire technology utilization program is reviewed to place the RDC work in proper perspective and to illustrate the interrelationship between this work and the technology utilization program as a whole. In addition, recent historical developments related to technology transfer (e.g., the evolution of computers) are summarized to explain the basis of RDC operations. It is concluded that the RDC's play a significant and promising role in the technology utilization program, but that more time and further studies will be needed to fully evaluate their effectiveness. Specific suggestions are made concerning these further studies.

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FOREWORD

This study was performed by Dr. John Geise and his associates of the Governmental Affairs Institute. The Regional Dissemination Center program presently constitutes one element of the NASA Technology Utilization Program which by virtue of its six year existence provides the longest historical basis for evaluation. As an experimental program, RDC successes and failures, the result of "learning by doing," have been documented and recorded, and the records were made available to the author and his research staff for comprehensive examination. The conclusions and recommendations are those of the author, who reached them independently following a period of interviews and exhaustive examination of records.

Ronald J. Philips, Director
Technology Utilization Division
Office of Technology Utilization

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Director, Special Studies Division

24 July 1970
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TABLE OF CONTENTS

Appendices

I. NEED AND OPPORTUNITY FOR TECHNOLOGY UTILIZATION

Industrialization, whose effective beginnings date back to the eighteenth century in Great Britain, is a continuing process that will increase both its demands and its contributions as far into the future as we now can foresee. A technologic-economic process, its successful application has created the difference between developed and underdeveloped nations today.[1] As knowledge advances, especially in the sciences and engineering, it is increasingly necessary that the resources of industry be adapted, expanded, and refined to make more effective use of new knowledge in producing new marketable products, improving products already on the market, and reducing the costs of production generally.

Although foreshortening of the period between the creation of new scientific or technical knowledge and its successful application for the market has long been desirable, neither the means nor the systems for accomplishing this have been available. The earlier effort of the Department of Agriculture, with its experiment stations, county agents, and pamphlets describing new methods and techniques, has proved successful in its field but the pattern does not meet the needs of modern industry, which are far more complex and sophisticated. However, some ten years ago the coincidence of four major trends created an opportunity for meeting industry's needs and the opportunity was seized by the National Aeronautics and Space Administration; the contemplated enterprise was such that it could scarcely be undertaken except by a major Federal agency. Originally, the end desired was the prompt and effective utilization of new scientific and technical knowledge for improving and expanding industrial production. As the program evolved, it became evident that the organizations and procedures it called for could be employed advantageously in contributing to solutions of some of our major national problems, such as transportation, urbanization, pollution, and crime. Because the over-all enterprise is so complex, NASA's activities in this increasingly critical area are just now getting under way.

The trends referred to above as creating an opportunity for action were of varying ages. The first got under way some two centuries ago and is relatively mature; the last is scarcely a quarter-century old but is strengthening at an extraordinarily rapid rate. They are as follows:

Industrialization - the complex process by which a nation's productive capacity is continuously expanded by the effective application of new technical knowledge by firms organized, staffed, and equipped to do so - has been competitive from the beginning. In each industrialized nation that operates on the free enterprise principle, competition for markets determines the success or failure of individual firms and the gross annual product of its several regions. On the other hand, competition between nations for increasing shares of the world market is also the rule, regardless of whether the competitors are free enterprise or totalitarian internally. Throughout the period since V-J Day competition at all three levels has been greatly intensified, especially at the international level. This puts a special premium on the prompt and effective utilization of new technical knowledge of all types. To date the United States has been outstandingly successful, as witness a statement from an official British report:

> The lead taken over the past two decades by the USA in tech-

> nological innovation, particularly in the newest industries, has been a major factor in her command of overseas markets in fields such as aircraft, nuclear power, computers, electronics and medicinal products. . . . Firms based in the USA have originated nearly two-thirds of the successful innovations made over the past twenty years, and also have the largest individual share, about one-third, of world exports in technically advanced goods. The proportion is even higher for some products, such as computers, which are immensely critical because of their pervasive influence throughout industry and commerce.[2]

If we are to maintain this position - and failure to do so would have serious effects on the national economy - the resources that American industry requires, including prompt access to and effective utilization of new scientific and technical information as it is produced, must continuously be strengthened. This holds not only for the large corporations in the fields of aircraft, nuclear power, computers, electronics, and medicinal products, but also for firms of all sizes in all industrial fields. As competition among the great industrialized nations continues to intensify, it becomes increasingly desirable that our national economy be so reinforced at all levels.

The second trend, which gives every evidence of continuing to gain strength, is that of the role of research and development as a progressively determinant factor in the progress of industrialization. Research and development, covering all the steps from basic research to the engineering development required for converting a laboratory prototype into a marketable item, was originally referred to as industrial research; if, for the period beginning in 1939-1940, this term is understood to include R&D for military and aerospace purposes, it is meaningful for this discussion. In its present highly-developed form, industrial research in the United States began in 1900, when the General Electric Research Laboratories were opened at Schenectady.[3] Because these laboratories quickly demonstrated their value to their parent company, the trend they initiated gained momentum rapidly. By 1928, in addition to the GE research laboratories at Schenectady, Lynn and Pittsfield, Massachusetts, and Cleveland, Ohio, twelve other major companies[4] had established comparable laboratories that were well staffed and profitably at work; the Mellon Institute of Industrial Research at Pittsburgh was servicing 53 industrial fellowships of varying size; some 300 smaller industrial firms maintained research laboratories of their own; approximately 300 university and college laboratories regularly performed research and testing for industrial organizations; a number of trade associations supported laboratory research; and the National Bureau of Standards, the Bureau of Mines, the Bureau of Chemistry & Soils, the Forest Products Laboratory, and the National Advisory Committee for Aeronautics of the Federal Government conducted research studies of great value to many fields of industrial activity.[5]

During the period since 1928, the pattern of company-owned R&D laboratories has been adopted by a steadily-increasing number of large and middle-size corporations and the size and range of activities of the laboratories already in existence have grown. In 1950, for example, the United States had some 2,500 industrial research laboratories, varying in size from the many with less than fifty employees to the few with more than five thousand. This was twenty years ago, and expansion has been continous ever since. As part of this expansion, research institutes, such as the Stanford Research Institute at Menlo Park, California, the Battelle Memorial Institute at Columbus, Ohio, and the Midwest Research Institute at Kansas City, Missouri, have been created as additional resources in all parts of the country, and research parks, such as the Research Triangle in North Carolina and Reston in Virginia, have further enriched the activity.

In addition, firms that specialize in R&D work only have appeared and many are quite successful, especially in the electronics and aerospace fields. The cumulative contributions of these various organizations leave no doubt about the great dependence of American industrialization on industrial research.

The third trend - namely, the entry on a grand scale of the Federal Government into R&D during World War II and its increasing activities in this area to date, especially after the Soviets launched Sputnik I in late 1957 - is really a phase of the growth in importance of industrial research. Be this as it may, the magnitude of the Government's effort along these lines warrants its consideration as a separate although related trend. The rate at which the Federal agencies are involved in R&D, as indicated by expenditures for research, development, and R&D plant, testifies to national recognition of the importance of R&D to the Nation's strength and security. In fiscal year 1940, for example, $74,100,000 or 0.8% of the Federal budget was expended for R&D. With few exceptions, each succeeding year produced an increase in both Federal R&D expenditures and the percentage of the budget they represented, until in fiscal year 1968 (the last year for which firm data are readily available) $17,030,200,000 or 9.5% of the budget was so expended.[7] The figure for 1968 should be compared with the $8,900,000,000 that private industry invested in R&D in 1968.[8]

The record thus shows that the Federal Government, although much later than private industry in establishing R&D as a major sector of its activities, nevertheless quickly became the senior partner in providing R&D support. However, this is not the significant point to be made here. It is rather that the addition of massive Government funds to the amounts industry was investing in R&D so increased the number of reports published on new techniques, procedures, materials, and devices that this information could not be exploited to the full advantage of the economy by use of the means then at hand. Published reports of advances in practically every field of research and development appeared in such quantities as to make impossible their prompt, let alone reasonably complete, coverage by an industrial scientist or engineer. This created the hazard that potential innovations could and in many instances would be pre-empted by faster-moving rivals in the international competition for industrial leadership and/or survival.

The origins of the fourth and last trend of the series in which we are interested dates back to the late 1880's, when Dr. Herman Hollerith invented a punched card system to store information for use in compiling the US census of 1890 and the American Arithmometer Company was organized to produce a comparable mechanical recording system. Hollerith's firm - the Tabulating Machine Company - and the American Arithmometer Company were the lineal ancestors of the International Business Machines Corporation and the Burroughs Corporation, respectively. The breakthrough that produced the first true electronic computer and so initiated the contemporary computer industry was achieved by Drs. J. Prosper Eckert and John Mauchly at the University of Pennsylvania where, in 1942-1946, they designed and built the ENIAC (electronic numerical indicator and calculator) for the Army. The company they organized to market their product after 1946 became the Univac Division of the Sperry-Rand Corporation when the latter was formed in 1955. By this time, as a result of intensive R&D work, IBM and Burroughs, together with other major firms such as the National Cash Register Company, the Radio Corporation of America, and the General Electric Company, had entered the electronic computer field and expanded it with startling rapidity. Whereas in 1950 there were only some 250 computers in the United States, today there are more than 75,000 in regular use, and the computer industry has become one of the largest in the country.[10]

This increase in the number of computers that are now available, great as it is, nevertheless is not the most significant feature of the new industry. To quote from a recent article in the Los Angeles Times:

> Present-day computers operate very fast and very cheaply. In 1960, a computer could perform 50,000 multiplications per second at a cost of about one dollar per 100,000 multiplications. Now, a computer can carry out 375,000 multiplications per second at a cost of about 20 cents per 100,000 multiplications. And this 20-cent figure is predicted to drop to about five cents in the near future.[11]

Other capabilities of contemporary computers, such as the retrieval of information, are roughly commensurate in both speed and costs. And this is the all-important contribution of the last of the four trends we have described, namely, the ability at very low costs of money and time to search enormous quantities of scientific and technical articles and retrieve whatever information is desired.

This coming to a common focus of these four trends about 1960 created an opportunity of immense potential significance, much as did a comparable but wholly unrelated series of trends that occurred much earlier in the process of Western industrialization. At the beginning of the eighteenth century, England's trade with the Americas, the Continent, Africa, and the East, built on accelerating entrepreneurship and victories in wars with commercial competitors, had become the principal source of her national revenue. A Civil War, followed by the Glorious Revolution of 1688, had laid the foundations for the development of responsible parliamentary government, with all the opportunities for the development of free enterprise in commerce and industry that eventually it provided. The movement of industrial leadership from London and the Home Counties to Lancashire, the Midlands, and Yorkshire had begun. Finally, the development of a source of artificial power - the steam engine - was successfully undertaken by Thomas Newcomen and by 1763 had been brought to a level of economic practicality by James Watt and Matthew Boulton. And so, some two hundred years ago, new technical knowledge, successfully applied, combined with development in other fields to initiate the first Industrial Revolution, the effects of which have transformed the world.

Industrialization, as has been noted, is not only a continuing and competitive process but also depends for success on the effective application of new technical knowledge for the expansion of production and the reduction of production costs. The example of England's experience in the eighteenth century parallels the situation we face today. Possibly at a lower level of ultimate significance but certainly essential to the continued strength and well-being of our national economy, the promotion of technology utilization by means of computerized retrieval of scientific and technical information, effective demonstration to industry of its practical use-value, and refinement and strengthening of the organizations designed to provide the services required, has been initiated by the National Aeronautics and Space Administration at a most opportune time.

II. NASA'S TECHNOLOGY UTILIZATION PROGRAM AS MATRIX FOR REGIONAL DISSEMINATION CENTERS

The National Aeronautics and Space Act of 1958, which created the National Aeronautics and Space Administration, instructed the Administrator to "provide the widest possible practicable and appropriate dissemination of information concerning its activities and the results thereof," to establish "long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes," and to make "the most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies in order to prevent unnecessary duplication of effort, facilities, and equipment."[1] It is quite apparent that in preparing these instructions to the new agency the lawmakers who drafted the Act had in mind the potential value to the Nation as a whole of a desired enrichment of the process of industrialization. They left to NASA determination of the specific objectives of this special mission, planning of the organization to perform it, and development of the procedures and techniques required for attaining its goals.

When James E. Webb became Administrator of NASA in February 1961, he interpreted quite positively these provisions of the Agency's charter.[2] The beginnings of one essential element of the organization called for were already at hand: The Research Information Division that had served the National Advisory Committee for Aeronautics had been carried over into NASA Headquarters as the Technical Information Division of the latter's Office of Business Administration,[3] and was actively engaged in processing the reports produced by NASA's laboratories and contractors and in providing channels for distributing the information they contained. In November 1961 the initial step was taken toward a program to produce more effective use of this rapidly increasing flow of information by establishing a small Industrial Applications unit in the Office of Applications.[4] At this time neither the extent to which these two organizational elements would have to be developed nor the extent of their interdependency was realized, but the beginning had been made. Since then, both have been greatly expanded and refined to function efficiently for technology transfer. In April 1963 they were brought together as coordinate divisions of an Office of Technology Utilization and Policy Planning[5] and, with modifications of title and expansion and refinement of functions, they operate together today.

In tracing the development of these offices of NASA Headquarters that direct NASA's technology utilization program, the rather many changes in location they have experienced within the Headquarters organization, changes in relations with other Headquarters Offices, and changes in leadership and titles will be passed over in favor of dating and identifying their principal operational functions as they have been added. Such administrative changes as were made should not have been unexpected in what was genuinely an experimental program evolved by a new agency with a hitherto unheard-of mission.

The challenge that NASA faced in 1961 was that of developing what has necessarily become one of the world's most sophisticated storage and retrieval systems for scientific and technical information, and complementing it by building an effective organization of highly-competent engineers, entrepreneurial managers, and administrators to direct the flow of carefully-selected items of this information to industrial firms, large and small, for effective use in the continued strengthening of the American economy.[6] Moreover, at this point in time the problem had not yet been defined, let alone the actions required for its solution charted. The undertaking, whose ultimate results may very well rival in long-range significance NASA's success in placing Americans on the Moon, was thus a complex experiment whose step-by-step progress required the maximum of controlled imagination, versatility, judgment, and patience.

As was indicated in Part I of this study, at the time NASA was established as a major Federal Agency, the accelerating rate at which new scientific and technical knowledge was growing created a pressing need for collecting and systematizing such information so that any item or part of it would be available on call. In terms of historical precedents, it can be argued that if NASA's charter, as drafted by the Congress, had not assigned this task to the Space Agency and if NASA had not responded as it did, the enterprise would soon have been undertaken by other hands.[7] Fortunately for the Nation, NASA has proceeded with vigor and enthusiasm, with most promising results to date.

The first phase of NASA's experiment was carried out during the period from 1961 through April 1963, when the two principal components - the Office of Scientific and Technical Information and the Industrial Applications Division - were brought together in a single Office of Technology Utilization and Policy Planning.

Apparently the first significant action to be taken in this phase came shortly after the creation in November 1961 of the Industrial Applications unit in NASA Headquarters. It was the designation of selected technical personnel in each of the Research Centers as Industrial Applications Officers. The duties of such an officer were to identify innovations, both major and minor, that his Center had produced, to supply sufficient information about each innovation to describe it adequately for a technically-trained person, and to submit the resultant report to the Industrial Applications unit in Washington. Renamed Technology Utilization Officers at a later date, they have played throughout a most important role in the technology utilization process.

The second action also was taken in November 1961, when the Office of Applications contracted with the Midwest Research Institute, Kansas City, Missouri, to conduct a regional technology utilization program for strengthening industry in Missouri, Oklahoma, Kansas, Arkansas, Iowa, and Nebraska, reducing the out-migration of technical personnel from these states, and raising the levels of employment and income there.[8] This contract established ASTRA (Applied Space Technology - Regional Advancement) as the first of NASA's Regional Dissemination Centers and, as such, the pathfinder for the RDC's that came later. One of its early contributions to this phase of the technology utilization process was the systematic screening of innovations reported by the Applications Officers of the NASA Centers in order to identify those with the greatest potential applicability by industry.[9] In 1963 this practice was institutionalized for the entire NASA technology utilization program.

In December 1961 the Technical Information Division (since May 1960 in the Office of Technical Information and Educational Programs)[10] selected Documentation, Inc, of Washington, DC, to establish and operate under contract an automated scientific and technical information center for storing and making readily available the rapidly-increasing quantity of data produced by NASA's space and aeronautics efforts. The contractor was required to select and acquire documentary materials to increase the NASA bank of scientific and technical information; abstract and index such materials; prepare magnetic tapes recording the accession numbers of abstracted documents; prepare printed announcements and indexes of newly-acquired documents; provide reference support; and compile bibliographies in specialized fields. The products were to be for use by NASA, NASA's contractors, other participants in the space program, and, on request, other members of the scientific and engineering communities.[11] The working relationship thus initiated has continued to the present, with the resulting facility (STIF - Scientific and Technical Information Facility) making major contributions to the advancement of NASA's technology utilization program.

In January 1962 the Technical Information Division arranged for STIF to make available the reports of NASA's Centers and contractors in both full-size copy and microform. This adoption of microform not only lowered the costs of storage and duplication but also provided reduced-size copy that could be read by use of relatively inexpensive equipment and which, moreover, could provide good quality hard copy.[12]

In February 1962 NASA initiated Flash Sheets for the general dissemination of selected technical information. Prepared by Applications Officers in the Centers, these were single-page descriptions of innovations produced by NASA R&D, each consisting of a brief but adequate description of an item or process and a statement of its space use.[13] As such, the Flash Sheets were the lineal antecedents of the more comprehensive Tech Briefs that were introduced in April 1964.

NASA's Technology Utilization Program

In April 1962 STIF, as planned by the Office of Scientific and Technical Information, assumed publication of Technical Publication Announcements (TPA), a journal of abstracts and indexes of NASA and NASA contractor's reports, issued semimonthly.[14] Distributed to NASA technical and administrative personnel, NASA contractors and subcontractors, grantees, and consultants, and many university and public libraries, and available by subscription or payment of single-copy costs, it was renamed Scientific and Technical Aerospace Reports (STAR) on 1 January 1963. As the major abstract journal for the great majority of all aerospace R&D reports, STAR rapidly attained great popularity because of its use-value in many fields; Rosenbloom characterized it as the primary mechanism for reporting new technology.[15]

In the late summer of 1962 the Office of Applications made a grant to the Denver Research Institute of the University of Denver to conduct a study of such actual transfer of technology from the space field as had already been accomplished. The purpose of the study was not only to identify and record such transfers but also to use the information gained to throw light on what was still a relatively unknown process. This contract is an early example of the imagination and ingenuity that have characterized the work of the men in NASA Headquarters who have been charged with developing effective technology utilization. The contract was completed by submission of a report of the findings in 1963.[16]

In December 1962 the Office of Applications contracted with Indiana University for establishment of a Regional Dissemination Center (ARAC - Aerospace Research Applications Center) to serve the industry of that region.[17] By the terms of the contract, ARAC was to receive regularly the magnetic tapes that STIF prepared for STAR (and ultimately were available for International Aerospace Abstracts) and to use the University's computers for automated retrieval of information needed. Like ASTRA in Kansas City, this second RDC to go into operation attacked its problems with judgment and considerable creativity. By mid-1963, for example, it had developed and put into use custom interest profiles (CIP's), a device by which the technical needs of an industrial firm could be matched with relevant abstracts from the NASA information bank.[18]

In January 1963 the Office of Scientific and Technical Information contracted with the Institute of Aerospace Sciences (which shortly thereafter became the American Institute of Aeronautics and Astronautics by merger with the American Rocket Society) for the semimonthly publication of a journal of abstracts and indexes of the open literature on aerospace developments and the production of accompanying magnetic tapes.[19] This journal, termed International Aerospace Abstracts (IAA), conformed to STAR's format and quickly became worldwide in coverage. In preparation for this move, NASA had developed standard indexing terms by means of which STAR and IAA were in all respects compatible; they were incorporated in a Subject Authority List (SAL), which was issued to guide the selection of indexing terms and thus facilitate the retrieval of indexed documents.

Keeping in mind the scope and complexity as well as the novelty of

PL 85-568's technology utilization requirement, the accomplishments of this first phase of the enterprise, from February 1961 through April 1963, gave good promise of eventual success. The initial step had been the creation in NASA Headquarters of the nucleus of a major office to be responsible for planning and directing the undertaking. The fact that this nucleus consisted of two as yet loosely-related organizations - the Technical Information Division in the Office of Business Administration and the Industrial Applications unit in the Office of Applications - testifies to the novelty of the assignment and the experimental character of the over-all project; at the same time, it indicates sound judgment in recognizing that solution of the problem would turn on two fulcra, namely, the collection and availability in usable form of the technical information needed and an organization and procedures for identifying such items of this information as would have the greatest probability of adoption or adaptation by industry, effectively bringing them to the attention of industrial firms, and designing and refining the transfer process.

Both organizations promptly attacked their problems. The Office of Scientific and Technical Information created by contract a Scientific and Technical Information Facility (STIF) to provide technical information services of advanced types, with instructions to computerize at an early date such operations as would benefit thereby. Within four months STIF greatly improved the format of the much-used aerospace abstract journal (TPA, then, after eight months, STAR) for free distribution within NASA and to NASA contractors and subcontractors and sale to others. Intended primarily for in-house use by NASA and NASA contractors (in which capacity it has maintained a high value), STAR, together with the magnetic tapes recording the accession numbers of the abstracts, was promptly adopted by the RDC's as their principal source of technical information. As NASA gained experience, it became evident that the process of technology utilization, in order to be effective, required ready access to technical information from sources other than NASA and NASA contractors' R&D; accordingly, in January 1963 the Office of Scientific and Technical Information contracted with the Institute of Aerospace Sciences for a journal of abstracts and indexes, with accompanying magnetic tapes, for the open literature on aerospace developments. It is not clear whether at this time it was recognized that effective technology utilization required also the availability of comparable information about advanced developments in other fields, such as chemistry and biomedicine, to the NASA information bank; nevertheless, the establishment of IAA was the first of a continuing series of expansions of that bank, to the great advantage of technology utilization as a process.

The first significant step taken by the Industrial Applications unit was basic and of constantly-increasing value; this was appointment of Industrial Applications Officers (later termed Technology Utilization Officers) in the NASA Research Centers, to identify innovations and provide descriptions of them for the Industrial Applications unit's review and processing for dissemination. The next step was unquestionably the most discerning of all the actions taken during this first phase of NASA's technology utilization program. It had long been recognized that the mere dissemination of printed information, technical or otherwise, without personalized contacts and skilled assistance in its utilization, gave small probability that any considerable part of it would be put to use. Accordingly, before the end of 1961 the Office of Applications contracted with the Midwest Research Institute for establishment of ASTRA, the first of its Regional Dissemination Centers, to provide such stimulation and services to the industrial firms in its region. A year later a contract was awarded to the Indiana University Foundation for the second RDC - ARAC, at Bloomington, Indiana. Both of these centers promptly demonstrated the advantages and indicated the necessity of carefully-planned entrepreneurial promotion and personalized services in developing technology transfer. Early in 1962 the Office of Applications provided for the preparation and distribution of Flash Sheets - single-page descriptions of innovations produced by NASA and NASA contractors that promised to have good potential for technology transfer. These were distributed to NASA technical and administrative personnel and to NASA contractors and subcontractors in order to promote utilization in work under way of developments already completed; as such, they were replaced in 1964 by Tech Briefs, which were somewhat more complete and were also made available through the RDC's and by sale by the Government Printing Office.

By such actions the cognizant offices of NASA Headquarters, in the amazingly short period of slightly more than two years, laid the foundations for NASA's development of technology transfer and, by the actions taken, created the over-all pattern of the program to be developed.

The second phase of NASA's experimental enterprise in developing technology utilization dates from the creation of the Office of Technology Utilization and Policy Planning in April 1963, in which the two major Headquarters components were finally brought together as the Office of Scientific and Technical Information and the Office of Technology Utilization. For the purposes of this study, this phase is considered as having continued to the present. As was done in summarizing the achievements of the first phase, the major actions taken to expand, refine, and so make more effective NASA's program for technology utilization will be dated and briefly described.

Early in the spring of 1963 the Office of Scientific and Technical Information, drawing on the services of qualified technical personnel in the NASA Research Centers, developed a pilot program for the selective dissemination of information (SDI). This was accomplished by preparing subject-matter profiles which then were matched by the computers at STIF with the relevant reports and other items indexed in STAR and IAA.[20] Produced on request, they provided readily-usable current awareness information in a considerable number of technical fields for NASA personnel and NASA contractors and subcontractors. This pilot effort led to NASA's SCAN program of today.

Shortly after its establishment, ARAC initiated a procedure that came to be termed retrospective search service. In effect, it is a primarily computer search of the available information bank to identify the abstracts relevant to solution of a particular technical, managerial, or marketing problem; as such, it is tailored to the special requirements of an individual client.[21] Once its character and use-value had been demonstrated, it was employed by the other RDC's as they were established and has quite satisfactorily met a special need of the technology transfer process. It should be noted here that the several RDC's have made many other contributions to the further development of technology utilization; however, regardless of their significance, these contributions will not be identified in this listing of actions but rather will be identified and discussed in the following Part III, which deals with the RDC's in detail.

In April 1963 NASA and AEC agreed to standardize the microminiaturized copies of their respective scientific and technical reports by the use of microfiche (a 4"x6" transparency carrying up to 60 pages of text, from which full-size hard copy can be made by suitable equipment). Subsequently, the Federal Council for Science and Technology directed all executive agencies to adopt this standard for their reports.[22]

As the number of innovations reported by Technology Utilization Officers in the NASA Research Centers increased, in the late spring of 1963 the Technology Utilization Division contracted with seven industrial research organizations to assist in evaluating innovations that had good potential for industrial use.[23] The information so obtained was essential to the selection of subjects for Flash Sheets and, beginning in 1964, for Tech Briefs. Some of the research organizations selected for this work are still employed for these purposes.

In the latter part of 1963, at the Office of Technology Utilization's request, it was decided that, beginning 1 January 1964, all NASA R&D contracts should incorporate a "new technology" clause, requiring the contractor to report in detail all patents, innovations, and state-of-the-art advances produced under his contract.[24]

Late in 1963 the Office of Technology Utilization initiated publication of Technology Surveys, which are state-of-the-art summaries that identify substantial technical advances in various fields of interest to industry. Revised periodically, they comprise a significant element of NASA's continuing publications and have many uses. At this time the Office of Technology Utilization also began publication of Technology Utilization Reports, which give detailed descriptions of especially-promising innovations. These also have been kept up to date.[25]

In January 1964 the Office of Technology Utilization contracted with Wayne State University at Detroit, Michigan, for establishment of the third RDC (CAST - Center for Application of Sciences and Technology).[26] During the next few months, two more RDC's were established by contract with the North Carolina Science and Technology Research Center at Durham, North Carolina (NC STRC - North Carolina Science and Technology Research Center),[27] and the University of Pittsburgh (KASC - Knowledge Availability Systems Center).[28] In March 1965 a contract with the University of New Mexico produced the sixth RDC at Albuquerque, New Mexico (TAC - Technology Application Center).[29] The seventh RDC was established in October 1966 by contract with the University of Southern California at Los Angeles (WESRAC - Western Research Application Center),[30] and in April 1967 a contract with the University of Connecticut at Storrs created the last RDC to be established (NERAC - New England Research Application Center).[31] This series of actions provided the Office of Technology Utilization with the entrepreneurial field agencies furnishing personalized services that its overall program required.[32]

In February 1964 the Office of Technology Utilization contracted with Southeastern State College at Durant, Oklahoma, to establish a facility which, although generally comparable in function to the other RDC's nevertheless has not been regarded by NASA Headquarters as a full-fledged RDC.[33] This facility (TUSC - Technology Use Studies Center) charges no fees to its clients because of the region's relatively low industrial level and, until 1969, its services were restricted to a 19-county area of southeastern Oklahoma.

In April 1964 the Office of Technology Utilization replaced the Flash Sheets that had been provided since February 1962 by Tech Briefs. The new documents described in greater detail such aerospace innovations of potential use to industry as had been selected by the joint efforts of the Office of Technology Utilization and the industrial research organizations working under contract on this task; many of them contained diagrams of the device or procedure reported, and all listed its patent status and stated where to write for additional information. Distribution was by a special mailing list of firms that had requested technology utilization publications, trade publications, and the news media; in addition, individual Tech Briefs were for sale by the Government Printing Office.[34] Shortly after publication of Tech Briefs was initiated, those of outstanding potential use were supplemented by Technical Support Packages (TSP's), which provided considerably more information than the original Tech Brief contained.

In March 1966 the question was raised in the NASA Authorization Hearings before the House Committee on Science and Astronautics of the RDC's eventually attaining a financial position by virtue of the fees paid by their clients that would enable them no longer to need NASA funds for their operation.[35] In response, later in that year the Technology Utilization Division, apparently without thorough analysis of the factors involved, notified ASTRA and the other RDC's then in operation that, after a given period of years (in ASTRA's case, three years) they should be sufficiently self-supporting as no longer to require NASA contract funds.[36] Adoption of this policy compelled the RDC's then active to change materially their philosophy of operations. The contracts for continuance of the work of ARAC and CAST that became effective in January 1967 required each to price its services in accordance with their actual costs, and subsequent RDC contracts have contained a comparable clause.

In the early spring of 1966 the Technology Utilization Division, expanding its coverage of potential transfer fields, instituted a Biomedical Applications Program to further dissemination of the findings of aerospace research in this field to biomedical researchers in the universities and medical research institutes of the country. In order to implement this program, small Biomedical Applications Teams (BATeams) were formed at Midwest Research Institute at Kansas City, Missouri, Research Triangle Institute at Durham, North Carolina, and Southwest Research Institute at San Antonio, Texas, to service biomedical researchers wherever located.[37] In most cases the searches of the NASA information bank that were called for were performed by appropriate RDC's.

At about the same time the Scientific and Technical Information Division supplemented the SDI program by developing Selected Current Aerospace Notices (SCAN). These differed from the SDI's in that they individually covered broader fields of technical interest and so were usable by a wider range of engineers and scientists.[38]

In the latter part of 1966 the Technology Utilization Division again expanded its coverage of potential transfer fields by initiating the COSMIC program, so named after the Computer Software Management Information Center that the University of Georgia established by contract to implement this program.[39] In the course of its over-all work since 1958, NASA had developed many advanced computer programs and procedures, information about which could be used most advantageously in many nonaerospace areas. On request, COSMIC made such information available at moderate costs.

Toward the end of 1966 the Technology Utilization Division contracted with Oklahoma State University for a 2-year feasibility study of introducing the results of NASA's R&D into college classrooms by arranging for their incorporation in standard engineering textbooks and preparing instructional monographs for use by engineering students.[40] The work thus initiated has been promising but as yet little definite progress has been made.

In mid-1967, with the approval of the Technology Utilization Division, the directors of the RDC's agreed to hold quarterly meetings to discuss their common problems and exchange information about techniques and procedures. To this end, they organized an association termed ACORDD (Action Council of Regional Dissemination Directors).[41] These meetings have been held regularly, with representatives of the Technology Utilization Division attending, to the advantage of all concerned.

NASA's Technology Utilization Program

Late in 1967 the Scientific and Technical Information Division published the first edition of the NASA Thesaurus, which superseded SAL.[42] Based on the STAR and IAA indexing from 1962 through 1966, this 3-volume document contained approximately 15,000 indexing terms, scope notes, lists of subject categories, and appropriate cross-references.[43] It was immediately put to use by STIF and the RDC's for guidance in subsequent cross-referencing and the retrieval of aerospace information.

Beginning in 1968, the Technology Utilization Division took positive action to broaden the coverage of the information bank available to the RDC's so that each would have a "one-stop" capability for its technical information service to clients. Prior to this move, normally the only recourse an RDC had for supplementing the STAR and IAA tapes was manual search of other index and abstract services; KASC, for example, since 1966 had been making such manual searches of United States Government Research and Development Reports and AEC Reports and United States Government Patent literature.[44] Some of the RDC's, however, had already moved on their own initiative to obtain magnetic tapes of specialized report areas; for example, NC STRC began work in 1967 to obtain the ITT tapes for the abstracts contained in the Textile Technology Digest.[45] By 1969, however, magnetic tapes for ten abstracting or indexing journals were available for RDC use; for efficiency of operation, individual RDC's assumed responsibility for searching specific tapes for other RDC's and BATeams and TATeams as well as for themselves.[46]

On the basis of favorable experience with the BATeams that had been instituted in early 1966, in 1968 the Technology Utilization Division contracted with the Research Triangle Institute for establishment and direction of a Technology Application Team (TATeam). The purpose of the program it represented was experimentation with technology transfer for solution of the public sector's problem of air pollution. In 1969 two other TATeams were created at Illinois Institute of Technology Research Institute and Stanford Research Institute. All employ one or more RDC's for the computer searches they require.[47]

Also in 1968 the Scientific and Technical Information Division, after completing a series of tests, contracted for the development of a remote-control information system (RECON) by which an individual at a typewriter in, say, a NASA Research Center could have practically immediate on-line access to NASA's entire information base through the computers at STIF. The citations desired would promptly be displayed on the cathode-ray tube of the RECON console at the Center where the request originated. The RECON system is already in use.[48]

The principal actions taken during this second phase of NASA's development of technology utilization bear out the point made in the comments on the first phase, namely, that the accomplishments of the first phase had created the over-all pattern of the program to be developed.

NASA's Technology Utilization Program

The work of the period since the establishment of the Office of Technology Utilization and Policy Planning in April 1963 can be characterized as expansion, elaboration, and refinement of this pattern, accomplished for the most part on the basis of analysis, experimentation, and accumulating experience.

Apart from the expansion and consolidation of organization and supporting facilities and services, the most significant moves made were the creation of a national network of Regional Dissemination Centers, the broadening of the information base available to include most significant fields of scientific and technical activity, the stimulus provided for an amazingly rapid growth of national information services, the initiation of action to bring to bear accumulated R&D findings for solution of problems of the public sector, and rapidly-established recognition (which is not confined to the United States) of the role of technology utilization in the current phase of continuing industrialization. On the negative side there must be noted a certain slowness in recognizing that the NASA technology utilization program, by its very character, requires, for effectiveness as well as for efficiency, expansion to a Government-wide operation and the availability of scientific and technical information from all relevant areas, a lack of consistency in providing some services at no cost to the user while requiring other services of the same categories to be on a fee basis, and tendencies on the part of both Congress and NASA Headquarters to expect the RDC's, which are the cutting edge of the novel and far-reaching technology utilization enterprise, to become self-sufficient in what historically must be termed overnight.

The actions taken since April 1963, beginning with establishment of the Office of Technology Utilization and Policy Planning, support the premise that technology utilization is an integral process whose principal factors are the prompt provision of all the scientific and technical information required, entrepreneurial activities to promote the effective utilization of such information by industry and the public sector, and imaginative management to refine the structure of the over-all operation in order to obtain optimal acceptance and utilization of the process itself. Inasmuch as industrialization remains a national process, it follows that the entrepreneurial and management elements of technology utilization, which is the current incremental factor in industrialization, must be conducted on a national basis; contrariwise, the collection, but not necessarily the processing, of scientific and technical information should be worldwide.

As regards the provision-of-information factor, the achievements of the Scientific and Technical Information Division during this second phase have been outstanding. Not only have useful special-purpose devices, such as selective dissemination of information, SCAN, and RECON, been designed and put into use, but also microfiche, as a means of lowering costs and reducing the time required for obtaining hard copies of reports, and the NASA Thesaurus, which was needed for reliable indexing of reports, have been provided.

From the viewpoint of establishing technology utilization as an increasingly productive factor of present-day industrialization, the Technology Utilization Division's establishment of a national network of Regional Dissemination Centers was crucial. As has already been noted, the mere dissemination of printed information describing scientific and technical advances has a very low probability of producing technology transfers on a large scale. What is required, as the appended statements of men who have studied and have had experience with technology utilization as a process indicate,[49] is the ready availability of personalized services, not only to promote the idea of technology transfer but also to implement it effectively. The RDC's, together with the BATeams and TATeams in their special areas, are the technology utilization program's field agencies that provide these services. As such, they are indispensable to the over-all operation of the program.

As progress reports from individual RDC's attest from as early as 1965[50] and as the actions taken in 1968-1969 demonstrate, it must be recognized that the information base available to the RDC's must be sufficiently inclusive of the many fields of scientific and technical innovations adequately to meet the needs of RDC clients. In order to attain such coverage, it is not necessary that each and every RDC have its own in-house coverage of the necessary abstracting journals and their magnetic tape indexes; it has been arranged that in addition to STAR and IAA, which every RDC has and keeps up to date, individual RDC's specialize in such sources as Chemical Abstracts (KASC), the Engineering Index (ARAC), and DOD reports (NC STRC), and, on request from another RDC or from a BATeam or a TATeam, perform any particular search desired.

The impetus created by NASA's technology utilization program greatly stimulated the development of abstracting journals with magnetic tapes of the accession numbers of the abstracts each publishes. The initiation of STAR and its tapes in April 1962 and of IAA in January 1963, both of which were sponsored by NASA, led to imitation in at least eight other fields of science and technology, beginning in 1964.[51] In addition, a number of abstracting journals for which no magnetic tapes are yet available to the RDC's (Nuclear Science Abstracts is an example) are received by or are available to the RDC's; if they cover fields of interest to RDC clients, they must be searched manually. The computerization of abstract accession numbers for these journals, which is essential to efficient search operations by the RDC's, thus reflects a movement initiated by NASA. Not only does this over-all program have enormous implications for scientific and engineering research as well as for technology transfer, it also has greatly stimulated growth of the information industry and of its base, the computer industry, in the United States.[52] Although presented from a broader viewpoint than that of NASA's technology utilization program, the recent testimony of Thomas O. Paine, the Administrator of NASA since early April 1969, before the Senate's Committee on Aeronautical and Space Sciences, is both relevant and emphatic:

> An excellent example of space-stimulated technical progress is the impact of new space requirements on the computer industry. . . . Challenging the best talents of our Nation in this way - to produce both hardware and the programing that makes it useful - has helped the U.S. computer industry to attain its present dominant world position. . . . The economic health and growth of this vital segment of U.S. industry is creating significant national capital, now and for years to come. NASA is proud of the degree to which our stimulus and support of technological advance has encouraged and assisted the computer industry's growth.[53]

In addition, it should be noted that initiation of the COSMIC program by NASA in 1966 has had a positive but as yet unmeasured influence on both the information and the computer industries.

Accumulating experience with technology transfer for industry, plus the increasing number and availability of information sources about a great variety of technical and managerial innovations, led NASA in 1968 to initiate TATeams for service in solving problems of the public sector. Although this program is as yet quite small, its potential in such fields as the reduction of pollution and the improvement of mass transportation is most promising.

All of these actions and their results add up to increasing recognition in the United States and abroad, especially in industrialized countries such as Great Britain and Japan, of the fact that effective technology utilization is the current extension of R&D activities responsible for the continued strengthening of national economies.[54] On this point also, Dr. Paine's views of the significance of NASA-induced technology transfers are unequivocal:

> Some are real, some are prospective, some are still to be tested in the rigorous climate of a competitive marketplace. . . . Some may only find limited application; others may in time become the nucleus of new industries. In my opinion, however, the major justification for space exploration remains its first-order benefits to science, to technology, to new direct applications, and to future U.S. wealth and power. Some of the byproducts might have been developed in time without a space program, but we have at least accelerated the process by providing the challenge, and then systematically gathering, cataloging, and disseminating the resulting technical information to the people who can put it to early use.[55]

Because NASA's technology utilization program, as initiated in 1961, was a pioneering venture into hitherto unmapped areas, it should not have been expected to move promptly on all fronts. In particular, lacking the experience that would make possible penetrating hindsight, the NASA staff could not be expected to have recognized at once that their technology utilization program would eventually require Government-wide representation in order to be either effective or efficient. Furthermore, there is no indication that anyone in the Congress foresaw the need for such an eventuality. Nevertheless, the logic of circumstance has brought about a pragmatic approximation of such expansion. This has been accomplished in two ways:

first, by cooperation between NASA and another Federal agency in special fields, such as the NASA-AEC agreement of 1966 to publish joint NASA/AEC Tech Briefs; and, second, by making available to NASA's RDC's all Government-sponsored abstracting journals and/or magnetic tape services. In effect, these developments have constituted NASA's RDC's as the Federal field agencies for the entrepreneurial promotion of the utilization of Federally-produced scientific and technical innovations.[56] Progress to this end has necessarily been time-consuming, yet it has resulted from the need of meeting practical requirements.

A second point apparently represents less than full recognition that the entire NASA technology utilization program is an integrated set of interdependent operating elements. The reference here is to the policy, on the one hand, of providing all NASA-originated information sources (other than the magnetic tapes for STAR and IAA) and certain information services, such as SDI and SCAN, to all NASA contractors and subcontractors without charge and, on the other hand, expecting the RDC's to bring themselves to self-sufficiency by charging fees for the services they provide, which are based in large part on the same NASA-provided information sources. Because many of NASA's contractors and subcontractors are so staffed as to be able to make use of such information for technology transfer without recourse to the services of an RDC, a number of them are lost to the RDC's as clients; moreover, all these firms under such conditions tend to deprive themselves of the entrepreneurial services the RDC's offer - services whose principal objective is strengthening of the national economy. It can readily be understood how this situation came about; organization for the dissemination of technical information as such considerably antedated organization of the RDC's. Nevertheless, to the extent that in the long run the

RDC's are the principal agents on whose promotional activity and personalized services the ultimate success of the technology utilization program depends,[57] the situation described above should be corrected. In this connection, it should also be noted that the inclusion of a new-technology-reporting clause in all NASA R&D contracts, beginning 1 January 1964, emphasizes the need for assisting the RDC's to expand their clientele in all appropriate and proper ways.

On 8 March 1967 Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, submitted a prepared statement to the House Committee on Science and Astronautics which contained the following statement:

> In NASA, our Technology Utilization Program is designed not only to speed up the feedback from space research into other areas of technical application, but also to document the process and its results. By its very nature that program can, at most, uncover only a small part of the total return. Yet, what it does reveal is quite impressive.[58]

These remarks suggest the complexity of the undertaking, its pioneering character, and the enormity of the task in hand. In a paragraph preceding this statement, Newell cited the long delays between Faraday's invention of the electric motor (1821) and the generator (1831), on the one hand, and establishment of the electrical and electronic industries, on the other, and referred to similar periods of incubation in many other fields.[59] Reference also can be made to the time lag between Nicholas Appert's invention of food canning at the end of the eighteenth century and establishment of the cahhing industry in the early twentieth century,[60] and many other comparable delays between innovation and effective industrial application can be cited. Thus, even when the accelerating rate of technologic advancement that has characterized the twentieth century is taken into consideration, it follows that technology utilization, as a radically new factor in industrialization, must overcome a built-in reluctance on industry's part to accept its offerings. All this will take time as well as the imaginative planning that has already gone into NASA's pioneer program. Viewed from this position, NASA's acquiescence in the suggestion of a member of the House Subcommittee on Advanced Research and Technology on 7 March 1966 that the RDC's might soon be expected to be self-supporting betrays a serious lack of perspective and, in part, lack of recognition of the ultimate significance to the Nation of the undertaking NASA has in hand. The task of demonstrating the use-value of technology transfer to industry and the public sector depends for success on the work of the RDC's, and to be successful they need both time and continuing support.

This description of the objectives, stipulated and accrued by the logic of functional requirements, and the development of NASA's technology utilization program suggests the validity of the following premises:

a. That what was initiated as a program for the transfer of aerospace-originated new technology to industry and the public sector has, because of inevitable demands for access to information from all sources of new technology, become in effect a NASA-operated activity which draws on Government-wide and other information sources.

b. That, from this point forward, success of the over-all program in attaining its objectives depends largely on the work of the Regional Dissemination Centers and the performance of the BATeams and TATeams.

The national importance of NASA's technology utilization program derives from the fact that technology transfer within a complex economy that is based on all levels of R&D represents the current phase of development of the industrialization process. The success of the program depends in the last analysis on the effectiveness of entrepreneurial activity in the field, principally for the following reason: Whatever number of technical innovations are produced and available at any point in time, the success of a technology utilization program is determined by the proportion of transferable innovations that are put into actual productive use, whether single or multiple. From the experience gained to date, it is evident that performance of this function depends largely on performance of the RDC's in the field.

III. THE REGIONAL DISSEMINATION CENTERS: RECORD AND EVALUATION

At the beginning of the seventh decade of our century, which had already witnessed a far greater increase of man's knowledge than had any previous period of comparable duration, the National Aeronautics and Space Administration launched a program for applying to productive use in other areas the knowledge and skills already generated for aerospace purposes. This - NASA's technology utilization program - was so timely a response to the need for making socially-profitable use of the enormous quantity of new knowledge created at great cost by massive R&D programs that, if NASA had not satisfactorily met the challenge, circumstances and logic would have compelled some other agency to undertake the task. As has happened, however, NASA has rapidly gained so much experience and understanding in developing and operating its technology utilization program, which of necessity has incorporated use of the R&D reports, abstract journals, and computer tapes of the other Federal agencies as well as those of non-Government professional groups, that in effect the NASA program has become a national operation serving the country's industries. As such, it is closely observed and studied by the governments and industrialists of other nations and to varying extents it is being imitated abroad.

This program, whose development was briefly described in Part II of this study, is directed by the Office of Technology Utilization in NASA Headquarters. For operations, it utilizes a Scientific and Technical Information Facility to provide under contract the basic information services needed; Technology Utilization Officers in the NASA Research Centers to make preliminary identification of potentially transferable technology produced by NASA R&D, with seven research institutes under contract to review and refine such preliminary identifications and NASA's Technology Utilization Division to prepare and approve the resulting Tech Briefs; six Regional Dissemination Centers and one quasi-RDC, placed strategically across the country, which as contractor facilities are responsible for convincing industrial firms of the value to them of the technology-transfer process, for servicing the industrial firms in their general regions that as clients desire technology transfer, and, as field units, assisting in the further development and refinement of technology utilization; three Biomedical Applications Teams that work out of research institutes to disseminate new biomedical findings to researchers throughout the country; three Technology Application Teams, also working out of research institutes, whose function is assistance in utilizing new technology in solving problems of the public sector; a Computer Software Management Information Center, under contract with a university, to promote use of NASA-developed advances in computer programs and procedures; and a number of projects for studying the process of technology transfer and evaluating certain aspects of NASA's technology utilization program. These various facilities and groups constitute a remarkably well-integrated organization for furthering development of the process of technology utilization by experimentation and analysis while maintaining the system in operation.

It is evident that the ultimate success of this program depends on convincing sufficient industrial firms in particular and American industry in general that the concept of technology utilization is sound and that its efficient implementation is both practicable and profitable. Much already has been done to describe, analyze, promote, and constructively criticize both the concept and the efforts to date to put technology transfer into effect; witness, for example, the 160 English-language articles, books, reports, and official documents published on various aspects of this subject in 1960-1963, at the very beginning of NASA's technology utilization program, and note the accelerated rate at which such documents have appeared since the end of 1963.[1] With few exceptions, neither the University of Denver bibliography nor a more complete listing prepared for the 1960-1963 period cites the brochures or the progress reports prepared for restricted distribution by NASA Headquarters and NASA's Regional Dissemination Centers; also, none of the multitude of newspaper reports of technology utilization activities and their results are included.[2] For its part, NASA, either as NASA Headquarters, NASA Research Centers, or the Regional Dissemination Centers under contract to NASA, has held many national and regional meetings at which the objectives, procedures, and both anticipated and actual results of the technology utilization program have been presented; an increasing number of these in recent years have been devoted to technology utilization in special industrial fields.[3] Since 1964, NASA has conducted a vigorous program for the publication and distribution of Tech Briefs, documenting innovations produced by aerospace R&D that have potential for application by industry; to date, more than 18,000 such innovations have been identified and more than 3,000 of them have been documented as Tech Briefs, with some 38,000,000 copies distributed or sold.[4] Working at the level of face-to-face relationships with individual industrial firms, since 1962 NASA's Regional Dissemination Centers have been the principal field agents of the technology utilization program; in that capacity, they have identified many of the major problems that must be solved in order for this program to be truly effective and, drawing on their accumulating experience, have made valuable contributions to its operation. To the extent that personalized services are essential to realizing the full potential inherent in the technology utilization program, it appears that in the long run a major, if not the principal, responsibility for its success rests squarely on the RDC's.

As developed to date, a typical NASA Regional Dissemination Center is university-based[5] and is thus in position to make use of its present institution's computer center for searching magnetic tapes and making analyses. Its average age of operations at the end of May 1970 is 5.5 years, so that the RDC's still need much more experience in developing expertise in a hitherto untried enterprise. As regards functional structure, an RDC is headed by a director with responsibility for planning and operations and with a superior in the university (or state) administration to whom he reports.[6] As will be described in detail below, the basic operations of an RDC fall into three principal categories:

> Marketing, which is really a selling function with two objectives: persuasion of industrial firms of the practicability and profitability of technology transfer and obtaining clients for the RDC's services.
>
> Analysis or engineering: the servicing of a client's needs by defining his problem, developing a suitable search strategy to retrieve the relevant technical information from the over-all data bank, analyzing and evaluating the output of the search to select the most promising information for submission to the client, interpreting the information submitted (as needed), and doing all this on a personalized and continuing basis.
>
> Technical operations: in support of both marketing and engineering, all computer operations, including printouts of abstracts selected, maintaining computer tapes, abstract card files, abstract journals, microfiche, and printing publications, provision of microfiche and hard copies of documents requested, continuing cost analysis to determine and refine the fee structure, and over-all accounting services.[7]

In addition to these continuing functions, the director and his principal staff develop new services, improve services already established on the basis of special studies performed, modify the fee structure as required, plan successive phases of the marketing campaign, conduct experiments as required by NASA, work to broaden the information base available, and prepare regular and special reports for submission to NASA's Technology Utilization Division. Further, the director, as a member of ACORDD, meets regularly with the directors of the other RDC's and representatives of the Technology Utilization Division to exchange information, resolve common problems, and develop plans for cooperation and specialization in the interests of economy and efficiency. In addition to the full-time staff members utilized for the analysis (or engineering) function, qualified faculty members, engineering and business administration graduate students, and outside consultants are employed on a part-time basis as the director decides.[8]

This generalized description of a typical Regional Dissemination Center can advantageously be supplemented by citing exceprts from statements prepared by RDC's themselves. The first is ASTRA's own statement of its functions,[9] as follows:

> To relate new information, derived from one industry, to a specific need in another, requires a special point of view and the skills of technology transfer specialists. The role of the technology dissemination center is to provide this point of view and the skills necessary to catalyze the transfer process. The center fulfills two vital functions:
>
> 1. It assumes the task of collecting, cataloging, and screening the mountain of available technological information.
>
> 2. It catalyzes the transfer process by establishing links between unrelated industries, uses, and methods.
>
> Both functions call for a staff with inter-disciplinary training and experience, plus operating familiarity with a multiplicity of industrial operations and their interrelations.
>
> To build and maintain such a staff of specialist-general-

> ists is seldom within the capability of a single company. But it is possible for an institution receiving widespread government and industry support.[10]

The second is from the 6th edition of ARAC's operating manual:

> The design philosophy behind ARAC's services includes four features: (1) computerized retrieval of information from the sources available . . . , (2) an experienced engineer or scientist, acting like a colleague of the company man, operating on the input and output sides of the computer or making the search manually, (3) a set of services that communicate idea-generating information to the company man periodically, and (4) a set of services in which the company man "pulls" specific information out of the system for problem solving and other needs. The most important feature is, of course, the experienced ARAC engineer or scientist acting on behalf of the company man.
>
> The specific objectives of these activities are:
>
> 1. To aid in the development of new and improved products, processes, and materials for civilian markets.
>
> 2. To preclude duplication in research and development programs.
>
> 3. To insure the most effective utilization of company scientific and engineering talent by reducing the time they devote to searching for information.
>
> 4. To insure a state of continual awareness concerning the development of new technology.[11]

These two statements of the functions of an RDC represent no basic difference of principle. Nevertheless, ASTRA and ARAC followed two quite different lines in developing their services to clients. ASTRA placed major emphasis on personalized interpretive services as its program progressed, while ARAC resorted more and more to standardized procedures. According to ASTRA's final report, during the first five years of its operation the value of its services to clients increased consistently, because the clients (to whom no fees were charged) were given personalized assistance in solving specific problems rather than being provided with large quantities of information that would have required excessive time and considerable skill to analyze, digest, interpret, and put to use.[12] When, in April 1966 and in compliance with NASA Headquarters' requirement that each RDC should become self-supporting as soon as possible, ASTRA established a $500 annual membership fee, its clientele fell from 840 to 45 by January 1967; further, when, in April 1967, ASTRA went on a cost-of-service basis, the number dwindled further, to 8.[13] For its part, ARAC responded to NASA Headquarters' self-sufficiency requirement by resorting to increasing reliance on standardized (and therefore depersonalized) services by substituting standard interest profiles for custom interest profiles. As a result of the economies thus attained and therefore a commensurate reduction of fees, ARAC increased the number of its clients considerably and now has greater income from industry than any other RDC.[14] ARAC's decision should not be interpreted as complete withdrawal of personalized services, but rather as a measurable reduction thereof. It should be added that, given NASA Headquarters' insistence on the attaining of self-support, most of the other RDC's have followed ARAC's example. It is questionable whether NASA's action at this early stage of the technology utilization program furthered attainment of the long-range goal of winning industry's general acceptance of the practicability and profitability of technology transfer. On this general point, it is interesting that TUSC - the Technology Utilization Study Center established at Southeastern State College in Oklahoma in early 1964 - continues to charge no fees to its clients, the reason being that this quasi-RDC is an experiment in assisting small businesses.

It is apparent that development of the technology transfer process can be approached from either end: the needs and interests of industrial firms as a basis for action to meet them or the publication of descriptions of innovations in the hope that many will be adopted by industrial firms. The first of these approaches has been taken by NASA's RDC's, BATeams, and TATeams, the last, by the Technology Utilization Division's review of some 90,000 research reports from NASA laboratories and contractors, distribution of some 3,000 Tech Briefs and a significant number of special publications dealing with specific areas of technology and state-of-the-art reviews, conferences and symposia on a variety of technologies and various aspects of the technology transfer process, and interchange of people between NASA laboratories and industry to promote cross-fertilization of skills and experience.[15] To be sure, the conferences and symposia listed in the second group are held to promote acceptance of the technology transfer concept, but it nevertheless is increasingly evident that the approach of the RDC's, the BATeams, and the TATeams is essential to the ultimate success of the technology transfer program; witness the statements cited in Appendix D and also the conclusion advanced by Daniel L. Spencer at the Denver Research Institute conference at Snowmass-at-Aspen, Colorado, in September 1969:

> Our conference has confirmed what a lot of us have suspected, that something more is necessary for technology transfer to be effective. That something more is the personal element, communication between people. And to understand technology transfer better, we must shift our base to the demand side, the users. This should be the research strategy for the 1970's.[16]

Spencer's view, which parallels the conclusions of this study, calls for a detailed description of the basic operations of the typical NASA Regional Dissemination Center.

Of the several functions performed by an RDC, the most important is the convincing of individual industrial firms in its region that technology transfer is practicable and also will be profitable to them and, as a result, obtaining as many firms as possible as fee-paying clients. This is accomplished by a variety of means. For example, conferences of industrial representatives[17] are held at which the quantity and types of new technology that have been documented are noted, the process of technology transfer is described,the services provided by the RDC and the uses to which they are put are outlined, and instances of actual transfer, together with indications of the results of each (reduction of manufacturing costs, improvement of products, development of new products, etc.), are stressed. Although such conferences are most important during the period immediately following an RDC's establishment, at any time they can be modified as deemed desirable to reach firms that to date have not been contacted. Each such conference is followed promptly by visits to the appropriate officers of each firm by the RDC representative most qualified to convince the firm of the value to it of becoming a client of the RDC; each such visit necessarily calls for an individualized sales presentation in some depth. The over-all objective of both the conferences and the visits to firms is really educational, but the success of the educational effort is measured by the number of firms that become clients. The reason for stating that this is the most important function of an RDC is implicit in the view that, at this stage of industrialization, our national economy must make additional profitable use of the new technology generated by the expenditure of billions of dollars over the last decade and still being produced. The RDC's as a group are the technology utilization program's principal agent for accomplishing this by working directly with industrial firms in all parts of the Nation. Furthermore, as the technology utilization program undertakes servicing the public sector to assist in solving such problems as pollution and mass transportation, the RDC's, supplemented by BATeams and TATeams, will have additional responsibilities of the same order.

Another function of major importance is the conduct of retrospective and current awareness searches of an RDC's available technical information bank in response to a client's request and to meet his specific needs. A retrospective search, normally undertaken to solve a particular problem, requires computer processing (supplemented when necessary by manual search) of a large part of the RDC's data bank; thanks to the recent specialization of individual RDC's in given fields (KASC, for example, handles the Chemical Abstracts Condensates), some part of the search may be performed by another RDC at the request of the RDC responsible. Inasmuch as STAR and IAA cover reports back to 1962 and many of the magnetic tapes for other fields also represent considerable time coverage, it requires seeking relevant information from hundreds of thousands of abstracts. This is because "new technology" for a client's use is not necessarily recently developed but rather is an item of technical information unknown to him. Current awareness searches, for their part, are designed to keep clients abreast of new developments in their respective fields of interest and involve periodic processing[18] of only the most recent additions to the data base.

A retrospective search for solving a particular problem (for example, finding a suitable material for a special purpose) calls for the RDC engineer who is planning the search to design a search strategy. This also is true for a current awareness search, but here the search strategy is termed either a custom interest profile (CIP) or a standard interest profile (SIP). A given search strategy may be developed, for example, by selecting from the appropriate thesaurus the keywords believed to be most pertinent to the subject of the search and then combining them according to Boolean logic. This produces a set of instructions to the computer and results in a computer printout of accession numbers of presumably relevant research reports.[19]

On the basis of the findings of a doctoral dissertation it sponsored,[20] ARAC, followed by some of the other RDC's, adopted a weighted (in place of unweighted) Boolean logic. In this system the engineer planning a search assigns a weight between +9 and -9 to each selected keyword in terms of its relative importance to the area to be searched; also, he assigns a cutoff weight so that any abstract whose cumulative weight is below this level can be rejected by the computer, and includes this cutoff in the instructions to the computer. On identifying the abstracts in accordance with its instructions, the computer totals the several weights for each (usually a single abstract turns up under more than one keyword), rejects the abstracts whose total weight is below cutoff, and then prints out the accession numbers of those thus determined to be most probably relevant.[21]

The following generalized account of how TAC conducts a search applies also to the other RDC's. TAC receives a client's request for a given search by mail, telephone, or direct conversation. After personal consultation with the client to make certain that the subject of the search is properly defined, a TAC engineer devises the search strategy to be employed. By resort to the NASA indexes that show how many documents are listed under each term, a TAC senior engineer evaluates the proposed search strategy to determine the probable extent to which the NASA data bank can satisfy the client's request. If the data bank is insufficiently responsive, he decides whether to augment the base by manual search of other technical materials[22] or to notify the client that a search would be unproductive. If the senior engineer's decision is affirmative, the instructions go to the computer. The computer output, consisting solely of the accession numbers of abstracts of research documents, goes to the engineer who had prepared the search strategy. The cards containing the abstracts selected by the computer are pulled and reviewed for relevance. Abstracts that have little relevance or duplicate other abstracts are rejected. The abstracts that remain, together with reprints of articles and other materials produced by manual search, are packaged and mailed to the client, along with a covering letter, an evaluation form, and a document request form. The evaluation form is designed to obtain the client's opinion of the value of the search's findings to him, and the document request form is for his use in obtaining complete copies of such reports as he may wish to study.[23]

Regardless of the care and skill with which a search strategy is developed, it has been inescapable that a considerable proportion of the computer output has either little or no relevance. As noted, however, this so-called "garbage" can readily be screened out by the engineer in charge. Of far greater importance is the possibility - and in many cases the probability - that important relevant citations may have been missed.

Recognition of this difficulty led KASC to study the feasibility of retrieving documents in the NASA information bank by use of other than conventional descriptors. In this experiment, conducted under a special NASA contract from January 1968 to October 1969, the texts of five different substitutes for conventional descriptors, namely, the citation, the abstract, the first paragraph, the last paragraph, and the first and last paragraphs of each of 1,195 documents were separately stored in machine-readable form, by means of which a suitable concordance of new-type descriptors was compiled. The results of searches made by strategies based on these several types of descriptors varied but indicated that none of these empirical methods was as successful as searches by use of conventional descriptors.[24]

However, this difficulty if not the impossibility of retrieving all documents relevant to a clearly-defined subject does not invalidate computer searching. Nevertheless, it does demand that indexing be brought to the highest level of reliability that can be attained. In addition, it emphasizes the need for the greatest care in preparing and refining individual search strategies. Finally, it calls special attention to the role of the RDC engineers in the over-all process of this type of computer operations; they probably have had more cumulative experience in this kind of work than any other group in the country.

In addition, this record of some of the major contributions to the process and practice of technology transfer made by the RDC's indicates the extent to which NASA is indebted to these agencies in the field. It also suggests the extent to which understanding of the problem and expertise for use in its solution has been cumulative in the RDC's, individually and as a group.

The last five paragraphs have been concerned principally with the use of computers for retrospective searches; now attention should be directed to the current awareness search, whose purpose is to keep a client or clients abreast of recent developments in the fields of their interest. Originally, as developed by ARAC, the current awareness search was designed for a single use and the search strategy on which it was based was termed a custom interest profile. In theory, a custom interest profile would seem to be the ideal means of retrieving from a data bank the citations or abstracts that would be most valuable to a particular client. In some instances it did just that, but all too often it failed to meet expectations. The principal difficulty stemmed from inability of the strategy designer to strike a happy balance between a profile that was too narrow and one that was too broad. A too-narrow profile might yield few or no citations, and one that was too broad would produce a sizable quantity of garbage. The net result was that the time spent in working with a client to define accurately his area of interest and in revising a CIP that failed to produce the desired results, inevitably drove up the costs of this service to a level where, by 1966, they had become prohibitive to many users. As a result of revision of the RDC fee schedules to reflect accurately actual operational costs, by 1967 CIP's became prohibitively expensive for many more clients. By this time, however, the challenge had been met and most of the RDC's were able to offer a substitute current awareness service based on what subsequently became known as the standard interest profile (SIP).

The development of the SIP marked a most significant change in the RDC search procedure and to a considerable extent influenced RDC operations. Its introduction may reasonably be likened to the introduction of the Model T Ford into a field of largely custom-built automobiles; inferior in many respects to most of its competitors, the Model T nevertheless had greater impact on the auto market than all of the rest put together, because of its low cost and high reliability.

Although not named until 1966, in reality the SIP's had their origin in two special services devised by ARAC two years before. The first was a marketing information service, which provided information about the latest methods and techniques in marketing; this was distributed monthly to clients as a package of approximately ten abstracts of current articles on the subject. The second was a computer information service, also a monthly package designed to keep subscribers abreast of significant developments in the computer field. The significance of these two services lay in their usefulness to many client firms (rather than being specially-prepared services for a single customer). The relationship of these earlier services to the SIP's was indicated when ARAC formally announced the first series of SIP's in November 1966; the marketing information and the computer information services became SIP 74 and SIP 40, respectively.[25]

The first SIP's were developed by ARAC by combining the interests of a number of fee-paying clients who already were receiving an analogous output on a CIP basis. The great majority of these SIP's covered rather specific subjects, such as reinforced composite materials and temperature measurement. Each was a profile that ARAC knew by experience would yield a dependable output from the currently-available information file and also would interest a number of active clients, especially as standard production would reduce the clients' costs. Most SIP's provided monthly or semimonthly mailings of from 5 to 50 relevant abstracts. As the system was developed, the final step was semiannual publication of a guide to all SIP's currently available, consisting of a list thereof, a detailed description of the coverage of each, and an alphabetic list of the subjects covered.

Reception of the initial SIP's by ARAC's clients was quite encouraging. After all, at that time an SIP cost only $80 a year for semimonthly mailings, which compared most favorably with payment of from $195 to $895 a year (the actual rate being determined by the number of abstracts provided) for a CIP of like frequency. Between March 1967 and January 1968, the number of SIP subscriptions increased from 111 to 167 for 50 out of the 56 SIP's available.[26]

Subscription to an ARAC SIP service carried with it a number of possibilities of personalized service to the subscriber as well as the opportunity to obtain at no cost hard copies of complete reports whose abstracts had aroused the subscriber's interest.[27] At a client's request, an ARAC engineer would be available to plan such further service as would be needed, such as a special current awareness search to identify related abstracts in an area not covered by the SIP or, on the other hand, a retrospective search to produce all abstracts in the files that related to the subject of the inquiry; such services, of course, would increase the client's costs. From this viewpoint, the SIP became a factor in ARAC's marketing program, a factor that, as far as has been ascertained, has not yet been measured and probably has not been sufficiently emphasized in RDC promotional literature.

The initial group of 32 SIP's that ARC had provided were developed with fair ease, but additions to the list required considerable imagination and analysis. By February 1968 ARAC considered that its current list, numbering 56, represented the practical limit of subject coverage. However, repeated users' requests for expansion of the information base opened the way for further development. In October 1967 ARAC, in response to these requests, had added the published abstract journals for the DOD and Nuclear Science Abstracts files, which, although they had to be searched manually, increased by 30% the average number of abstracts in each SIP package. When, early in 1969, ARAC received the Engineering Index Compendex, its engineers quickly developed 20 new SIP's, some of which matched SIP's already developed from the NASA file.[28] Some of the early SIP's have been dropped or consolidated with others, but the latest report records 78 ARAC SIP's for subscription.

The SIP's thus pioneered by ARAC proved so successful that most of the other RDC's, at varying times, added them to the services they were providing, paying ARAC for furnishing the packages. WESRAC, which adopted them at an early date, publishes its own catalog of SIP's, but the extent to which the other RDC's advertise this service varies widely.

The popularity attained by SIP's with most RDC's and many of their clients is explained by the very considerable cost differential between CIP's and SIP's and, from the viewpoint of the RDC's, the extent to which they attract subscribers. In terms of their role in expanding acceptance of the concept of technology transfer, they are information service devices which, if effectively promoted, should in many instances lead subscribers to request supplemental personalized services; this should be most often the case when the subscribers are medium-sized or smaller firms. On the other hand, any emphasis in marketing SIP's that would play down the need for or value of other RDC services is questionable, to say the least. It is significant that ASTRA, which gravitated more and more toward the "interpretive and adaptive aspects of information transfer," never used SIP's. ASTRA's approach, however, must be weighed against every RDC's need for attracting clients. Thus the SIP is seen as useful up to a point, but also as a device with considerable potential for encouraging additional personalized services. The several brochures that have been issued to promote SIP subscriptions could profitably stress this approach by defining the full potential of the SIP service.

It should be noted here that the design and refining of search strategies and the development of CIP's and SIP's do not by any means constitute all of the principal contributions of the RDC's to the advancement of this essential aspect of technology transfer. Many other genuinely creative advancements of the art of computerized technology transfer have been made by individual RDC's during the last seven years; these advances, indicated in the listing on page 61, below, have done much to round out the process of technology utilization.

Record and Evaluation

Another relatively basic function of the RDC's is that of providing clients with microfiche or hard copies of the reports they request. As has been noted, a computer printout for a given search consists only of accession numbers of reports, by means of which either the abstracts of these reports or the reports themselves can be called for. When the relevant abstracts produced by a search are sent to an RDC client, a document request form is included in the package to facilitate obtaining complete reports in either microfiche or hard copy, if desired. Until the end of 1967 either microfiche or hard copies of reports in the STAR file were furnished by NASA at no cost to RDC clients; microfiche or hard copies of reports in other files had to be obtained from other sources and at varying costs. In January 1968, however, adoption of the general policy that RDC fees should represent actual costs changed this situation and at once placed a premium on reducing to a minimum the expenses of reproducing complete reports. ARAC, for example, established a rate of 50 cents per sheet for microfiche and one of 6 cents per page, with a minimum charge of $3.00, for hard copy. This and comparable rates set by the other RDC's were made possible by the installation of a microfiche printer and a microfiche duplicator by each RDC, NASA continuing to provide at no cost the basic microfiche for each abstract and report in its files. As the information base available to the RDC's was expanded by inclusion of other files, the problem of obtaining microfiche and hard copy reports became more complicated, but in large part has been handled by RDC in-house reproduction facilities.

Late in 1969 the Technology Utilization Division in NASA Headquarters funded a "centralized document proposal" submitted by ARAC, whereby it hopefully would be demonstrated that any RDC could obtain from ARAC hard copy reproduced from any microfiche available at Bloomington at a cost of only 3 cents per page; ARAC, for its part, promised 24-hour service. Development of the over-all procedure, by which certain economies could be realized by specialization and centralization, is under way.

Consideration of the principal functions of the RDC's, to be complete, calls for reference to ACORDD. As the number of RDC's slowly increased and it became increasingly clear that, regardless of location, they all faced many of the same problems, it was decided that a more-or-less formal association of RDC directors, with an ex officio representative of the Technology Utilization Division, would be most advantageous to all concerned. Regular meetings would make possible discussion of pressing matters of common interest, mutual benefits from each other's accumulating experience, and the development of plans for cooperation and specialization to eliminate duplication of effort. Accordingly, in 1967 it was agreed that regular quarterly meetings should be held and thus the Action Council of Regional Dissemination Directors (ACORDD) came into being. The minutes of each meeting have been faithfully circulated and a new era of cooperation and united RDC action began.

The ACORDD meetings have produced enlightening discussions of marketing problems as each director has related the successes attained and difficulties experienced in recruiting and retaining clients. The pros and cons of direct advertising have been debated, the reasons given for cancellations have been frankly compared, and specific proposals (as, for example, for a brochure on the RDC program and for a color film to publicize RDC services) have been made.

In line with the rationale developed by NASA's Office of Technology Utilization for the RDC's to provide "one-stop" service to their clients,

Record and Evaluation

ACORDD's active interest greatly facilitated the Office of Technology Utilization's efforts to make the DOD, Engineering Index Compendex, and Chemical Abstracts Condensates files available to all RDC's. Each of these tapes was provided to a single RDC, which then went to work under a special NASA contract to develop the computer software and processing procedures needed for the new file it had received for its own search system. Thus NC STRC became responsible for the DOD file, ARAC, for the EI Compendex file, and KASC, for the CA Condensates file. At about this time NC STRC obtained the Institute of Textile Technology file and incorporated it into its over-all search system, and other RDC's obtained the use of other tapes, such as NERAC for BA Previews (Biological Abstracts), WESRAC and NERAC for MEDLARS (Index Medicus), and NC STRC for ERIC (Research in Education). Cooperative arrangements have been made whereby, on request, the RDC possessing an additional tape, such as the CA Condensates, would make a search covering this tape for another RDC.[29]

ACORDD has also been active in promoting efficiency and economy in other areas. For example, when NASA stopped supplying printed abstract cards in 1968, it was found that considerable savings could be realized by having the reproduction of such cards from NASA microfiche centralized at ARAC and arrangements for this purpose were completed.

The creation of ACORDD has undoubtedly strengthened both the operations of the individual RDC's and advancement of the over-all technology utilization program. It also has underscored the importance to that program of the concept of a national RDC network, the nucleus of which is already in being.

Time and again, surveys conducted by the RDC's have shown that the number of industrial firms in a region that could advantageously utilize an

RDC's services is out of all proportion to the number actually being served. In early 1969 NC STRC identified 430 industrial prospects in the Southeast,[30] but on 1 January 1970 it had only 39 annual clients.[31] In early 1968 WESRAC located some 3,000 potential clients in southern California,[32] but on 1 January 1970 served only 31 annual clients there.[33] At the end of the period it was providing free services, ASTRA, in the Midwest, had 840 clients on its rolls.[34] The other RDC's show comparable disproportions between potential and actual customers.

Although the RDC's are to some extent competitive in seeking clients, the extent of the region each can exploit efficiently is definitely limited by distance from its location. Thus the fact that the RDC's are few in number, plus the need for personal visits to obtain and satisfactorily service a new client, minimizes the possibility of any one of them poaching on another's natural territory. In fact, the latest available statistics indicate that to a considerable extent each RDC's clients are located in the same state as the RDC. As of 1 January 1970, the record was as follows:[35]

ARAC	109 annual clients	32 in Indiana
NC STRC	39 annual clients	23 in North Carolina
KASC	56 annual clients	31 in Pennsylvania
TAC	28 annual clients	4 in New Mexico
WESRAC	48 annual clients	48 in California
NERAC	30 annual clients	10 in Connecticut

Thus, of a total of 310 annual clients of all RDC's on 1 January 1970, 148 or 48% were from states in which RDC's are located. Conversely, twenty states had no annual clients of any RDC.[36] This suggests that a basic problem of the over-all program is that a major effort must be made to reach all potential customers.[37]

Before turning to evaluation of the RDC's as a group, some attention should be given to the general types of difficulty the RDC program and the over-all technology utilization program faced at the beginning, and, in some instances, still have to overcome.

Back in 1961-1962, the principal problem of highest priority was created by the magnitude of the accumulated store of new technology (which, incidentally, has been added to ever since and certainly will continue to expand). This information had to be processed for computer analysis, with all of the supporting services (such as the provision of descriptors and indexes in thesaurus form and the detailed indexing of abstracts or reports) that were required; secondly, the RDC's had to develop various types of search strategies by which they could retrieve all the relevant abstracts and full reports they would need for any particular purpose. The first of these solutions, with the exception of fully reliable indexing, has been quite satisfactorily provided by the Scientific and Technical Information Division and its contractor, the Scientific and Technical Information Facility, and the services they furnish are being constantly improved and refined. The second phase, namely, the development of reliable search strategies, with all their supporting services, has also been in large part resolved by the RDC's themselves, yet much remains to be done. In general, however, the basic need of providing scientific and technical information in usable form has been met with reasonable satisfaction.

The second principal problem was not so demanding of prompt solution but in the long run will have a much more significant bearing on the success of technology utilization in the United States. In brief, it is the overcoming of industry's apparently inherent inertia in accepting and making full use of novel procedures or generally unknown techniques. The time lag that characterized the full development of both the electrical and the canning industry, referred to in Part II, above, is typical of the results of such inertia. To be sure, NASA's success in creating a full-blown aerospace industry, even though it was preceded by significant buildups in the missile and electronic fields, is an exception to this general principle, but it must be recognized that NASA's amazing achievement was made possible by almost unqualified and most exceptional national support at all levels.[38]

Granting that the validity of this principle has been demonstrated by the historical record, it must be recognized that the present-day pattern of American industry is a major factor influencing acceptance of the concept of technology transfer. To date, the successful transfer of new technology from one industrial area to another has been exceptional rather than the rule. Normally, it has required some form of redevelopment in order to obtain usable results; that is to say, it has called for the services of engineers and scientists who have the imagination, know-how, and experience needed. However, the great majority of the industrial firms in the United States are not staffed to accomplish such adaptations. Some industries are far ahead of others in this respect and, in general, the larger firms in each industry have a distinct advantage by virtue of their engineering staffs. Of the sixteen major categories into which American industry is broken down for reporting and analytical purposes, six employ 75% of the national total of engineers and industrial scientists. Also, the larger companies in each category, regardless of its over-all rating, have a disproportionate share of these engineers and scientists; for example, in the aircraft industry 13% of all employees in firms of more than 1,000 workers are either engineers or scientists, whereas engineers and scientists make up only 4% of all employees of firms with less than 100 workers. Furthermore, the industries best equipped to benefit from technology transfer are not necessarily the leading contributors to growth of the gross national product; three industrial categories (aircraft, electronics, and instruments) performed 62% of all industrial R&D in 1962, yet they accounted for only 15% of the dollar value by which manufacturing increased the GNP. The ten industrial categories that added 59% of the dollar value that year performed only 8% of industrial R&D.[39]

A 1967 study of the tool-and-die industry indicated how difficult it is to transfer technology for the benefit of small firms. This industry is dominated by such firms, and the study showed that few of their managers had ever head of important new advances in tool-and-die making that had been fully reported in popular trade journals. When these were called to their attention, most of the managers were reluctant to establish even a one-man technical staff to keep abreast of new information, their reason being unwillingness to incur the cost of any employee who would not contribute directly to production.[40]

On this general point, it is questionable whether even the large companies are initially interested in the kind of technology transfer that would lead to technological breakthroughs, even though, if successful, they would create new products, expand employment, and augment the GNP. What these firms generally are hoping for as the result of technology transfer is incremental improvements in the products and processes in whose production they are already experienced.[41] This is not surprising, for the members of a large firm who are theoretically most involved in potential technology transfer are usually engineers and industrial scientists engaged in solving specific R&D problems and the librarians and technical information specialists who serve them. Top management, which alone can approve the development of new products, is seldom involved. For many large firms that are entrepreneurially-oriented, this would pose no major problem, but for many others the risks involved - the chance that a new product might not be profitable or, contrariwise, that it might kill off an already profitable item on a firm's list - would be overriding. However, the threat of foreign competition would always be an influencing factor.

Still another obstacle in the way of developing effective technology transfer on a large scale is in the nature of the potential transferees. It has already been noted that many of the small industrial firms are unaware of the existence of new technology. The large firms who employ professional engineers and industrial scientists are fully aware of it, but these men tend to regard themselves - and are regarded by others - as specialists and experts and, as such, are often reluctant to seek assistance from outside their firm. As NERAC notes:

> It is therefore difficult to visualize such an engineer or scientist saying to his supervisor or employer that he needs the services of a Regional Dissemination Center to enable him to "keep up" in a field in which he is an "expert." To do this, the engineer or scientist would have to be secure in his relationship with his employer and an acknowledged leader among his peers. Conversely, for an employer or supervisor to suggest to one of his technological personnel the use of a Regional Dissemination Center's services would be most difficult if there be an implication or inference of inadequacy.[42]

This interpretation of the sitation, although basically sound, nevertheless represents argument from a false premise. Actually, RDC salesmanship should be so designed as to preclude the opportunity of an expert concluding that his competence has been impugned; for example, emphasis should be on the provision of supplemental services by which the expert's time could be saved, such services to be performed by a unique type of specialists whose specialty and facilities have only recently been created. As a matter of fact, it appears to be that many engineers and industrial scientists, for all their professional training, are not accustomed to systematically surveying the findings of others before beginning work on a problem. As recently as late 1967, WESRAC found it to be inordinately difficult to convince industrial firms of the desirability, let alone the economic necessity, of making such searches:

> The hours spent to educate users on the application of technology performed by others appears to be the most serious problem in the transfer of technology. This requires a change in habits that seem to be thoroughly ingrained. It does not appear that individuals in business, and particularly skilled scientific and engineering people, have the habit of investigating a problem to see if an answer has already been found before starting in to do it themselves.[43]

This identifies one of the factors, if not the principal factor, accounting for industry's inertia in adopting new technology that is available to it.

In discussing this general area of the difficulties the RDC's have faced, two points of general significance require mention. Firstly, when NASA undertook its technology utilization program in 1961, it underwrote a research-institute-based Regional Dissemination Center to assist in implementing it and in the next three years established five more centers, all university-based. Reliance on universities as bases for RDC's assured practical benefits to both parties. As the RDC's gained skill and competence, it became evident that NASA had built far beyond its initial hopes. In one sense, this is now recognized, for NASA's support of broadening of the information base needed by the RDC's, which began in 1968, and its initiation of BATeams in 1966 and TATeams in 1968 were actually a further application of the principle of RDC operations to new fields. In another respect, however, NASA has taken an unrealistic view of its RDC's. Since 1966, it has tended to measure their success chiefly by reference to their progress toward financial self-sufficiency, thereby disregarding to a considerable extent the obstacles, such as the traditional reluctance of most industrial firms to adopt at once a novel procedure, however promising in the long run it might prove to be. Granted that some of the RDC's had not given sufficient attention to their educational (that is, marketing) responsibilities, this was unfortunate in that it inevitably encouraged the RDC's to put quantity before quality; their unique function in the process of technology utilization is - and must continue to be - provision of skilled and imaginative personalized service. It induced them to take the short view instead of planning for continuously improved and thereby expanding operations.

By allocating rather more than $9,500,000 in nine years (a miniscule sum by the standards of the 1960's),[44] NASA created and firmly established a network of university-based computerized technical information dissemination centers, staffed by experienced specialists who became increasingly competent in assisting industrial firms to improve production and develop new products. However, as has been indicated above, these field activities of NASA's technology utilization program are still in the formative stage of expanding and refining their procedures and lines of attack and, as such, will require support other than clients' fees for some time to come. Their potential, already demonstrated by their contributions to the technology utilization program and their successes to date, justifies continuing support and considerably more official recognition and publicity than so far they have received. This last point - greater official recognition and publicity - is important as a means of increasing the effectiveness of the RDC's; a special NASA brochure on the RDC's would be a good beginning.

* * *

Record and Evaluation

The character, functions, and role of the RDC's as a major and integral part of NASA's technology utilization program having been presented, evaluation of their performance to date is in order. Despite the fact that ASTRA, the first of them to be established, would be slightly less than ten years old were it in operation today, the contributions these centers have already made in advancing technology utilization are both significant in number and most timely in demonstrating what must be accomplished on a larger scale in order for the program fully to perform its functions. To date, they have carried a major part of the load of acquainting both American industry and the public at large, insofar as that has been accomplished, with the nature and potentialities of technology transfer.[45] To the extent that the enormous accumulation of new technology is a principal resource for further regional and national industrialization in a world characterized by intensive competition, the importance of the lines of action already demonstrated by NASA's RDC's should not be minimized. On the other hand, these field agencies are so novel in character and function, so young in experience, and so few in number that no sound means of subjecting their contributions to quantitative measurement can be developed. The over-all process of technology utilization, let alone the role therein of individual RDC's, is of such recent origin as to preclude this; of NASA's six RDC's, three have been in operation less than five years. It follows, then, that evaluation should consist principally of demonstrating the extent to which and the means by which they have advanced technology utilization in the United States and noting the individual contributions that each has made.

This approach is also recommended by another set of circumstances. Throughout the period of full operations of an RDC, only a relatively small part of its operational time has been pointed directly at promoting specific technology transfer by providing problem-solving retrospective searches.[46] By far the greater part has been devoted to current awareness searches, state-of-the-art surveys, and other services which, however valuable they are in keeping a client up-to-date in his fields of interest and in stimulating his engineering creativity, most generally have a less direct effect in promoting transfers; moreover, any transfer that did result from these other services would be extremely difficult to trace back to its source.

Accordingly, the following evaluation (as defined) of the NASA RDC's that are currently active will consist of identification of their activities for establishing the concept of technology transfer as a viable and needed element of continuing industrialization and at the same time for gaining clients and industrial income; identification of the services they have designed and put to use to meet clients' needs; comparisons of the currently-active RDC's as regards the number of their annual clients and ad hoc clients (the last for only 1969); and comparisons of these RDC's in terms of total industrial income.

To begin with the principal efforts of the currently active RDC's that were designed to promote acceptability by industry and the public sector of the concept of technology transfer and thus to obtain fee-paying clients to support their operations: In terms of information found in the quarterly, annual, and special reports of RDC's, wherever a particular center has been more or less outstanding in pursuing a given type of promotional activity,[47] it is identified at the end of the entry.

a. Conferences with industrial and civic leaders and local and state economic development groups, especially during the early years of an RDC's operations: all, with ARAC outstanding.[48]

b. Direct-mail solicitation of interest: all, with KASC outstanding.

c. Personal discussions of RDC services and operations with management personnel, engineers, and/or information specialists of prospective and actual clients: all.

d. Distribution of up-to-date brochures giving essential information about an RDC and its services: all.

e. Distribution of up-to-date catalogs of services and operational manuals: all, with ARAC and WESRAC outstanding.

f. Distribution of NASA technology utilization publications, including Tech Briefs: all.

g. Advertising in newspapers and trade and professional journals and on TV and radio: WESRAC outstanding.[49]

h. Stimulation of descriptive articles in newspapers, local and regional journals, and/or university publications: all.[50]

i. Conducting planned tours of an RDC for invited representatives of firms and other organizations: all, with ARAC outstanding.

j. Residency programs for individuals interested in technology transfer: ARAC.

k. Part-time employment of graduate students: all.

l. Part-time employment of faculty members as technical specialists and in other capacities: KASC and WESRAC outstanding.[51]

m. Performance of searches for graduate students: NC STRC on an institutionalized basis.

n. Performance of searches for faculty members: all, with NC STRC and NERAC outstanding.

o. Providing assistance in establishing university courses in technology utilization, including information science: KASC and NERAC outstanding.

p. Providing assistance to the State Technical Services Program and/or conducting an STS operation in whole or in part: all, with ARAC and TAC outstanding.

q. Working with state or regional agencies other than STS: NC STRC and TAC outstanding.

r. Integration with a university base: KASC, NERAC, and TAC outstanding.

Record and Evaluation

Although these activities are not equally effective in promoting the concept of technology transfer and despite the fact that not all of them are carried on by all six of the RDC's (or, for that matter, conducted at the same level of intensity), the number and variety of those that are listed above indicate both the energy and ingenuity with which the RDC's as a group have pursued this phase of their work. From the standpoint of making technology transfer viable, this is of inestimable value because it is a grassroots effort to reach and involve as many firms and public agencies as possible throughout the country and, in doing so, to lay the foundations for national interest in and appreciation of the potential value of technology utilization; the positive response to The Wall Street Journal's article of 27 March 1970 as an indication that both of these goals are attainable. The extent to which advantageous secondary use for industrial and social purposes can be made of the enormous and still accumulating store of new technology, already paid for or being paid for, depends in large part on popular as well as industrial recognition of the practicability of technology transfer, and it is to this end that the activities of the RDC's listed above are of real significance. Note in passing that they include such items as the part-time employment of graduate students and faculty members in RDC work, the assistance in developing and establishing university and college courses on one or more aspects of technology utilization, residency programs at ARAC, performance of searches for degree candidates and faculty members, and integration of RDC's with the university of which they are parts; all of these activities are directed at broadening the base of interest, understanding, and capabilities that technology utilization requires for future advancement.

The second group of accomplishments of the RDC's is the services they have developed in order to provide effective assistance to their clients, industrial and public, at minimal costs. As was true of the promotional activities already surveyed, this list is quite long and very interesting. Possibly its most significant feature is the extent to which it represents new and practical applications of computer techniques in operations requiring the action of both experienced technical and scientific specialists and computers as partners in psychomechanical systems.

The following services are listed by the RDC that initiated them and the year they were introduced in operations (all have been described earlier in this Part):

Computer searching: ARAC, 1963
Retrospective search service: ARAC, 1963
CIP current awareness service: ARAC, 1963
Industrial applications service: ARAC, 1963
Marketing information service: ARAC, 1964
Computer information service: ARAC, 1964
SIP current awareness service: ARAC, 1966
Abstract packet service: KASC, 1966
Natural resources program: TAC, 1967
Retrospective search service for graduate students: NC STRC, 1967
Management science service: ARAC, 1967
Retrospective search service for faculty members: ARAC, 1967 (following TUSC, 1966)
Urban planning bibliographies: ARAC, 1967 (following CAST, 1966
Addition of ITT file to information base: NC STRC, 1968[52]
Addition of DOD file to information base: NC STRC, 1968
Addition of EI Compendex to base: ARAC, 1969
Addition of CA Condensates and Chemical Titles to base: KASC, 1969
Abstracts for NASA/SCAN: WESRAC, 1969
Translation service: NERAC, 1969

A major factor in evaluating the performance of the RDC's is the success they have had in acquiring both annual and ad hoc clients. The prob- of dealing with this is complicated by several circumstances. First of all, the RDC program, as originally introduced by the establishment of

Record and Evaluation

ASTRA in late 1961, was set up to provide RDC services at no cost to participating companies. As a result, ASTRA readily built up a client list that by early 1966 numbered 840 and the concept of technology utilization was gaining considerable acceptance in the Midwest. However, when in 1966 overall policy was changed to require payment for RDC services, a major and not unnatural reaction occurred; by 1967 the number of ASTRA's clients had dropped to 45 and, when ASTRA closed in 1968, only 8 clients were still on its roster. The only other full-fledged RDC that started operations on a no-charge basis was NC STRC, which opened in 1964; when, in 1966, it established a fee schedule for services, it was handicapped for some years in building clientele. The questions raised by these experiences, are as follows:

a. Was NASA's original policy of providing RDC services without charge a sound and necessary policy to be kept in effect? It apparently represented recognition of the major advantage to be gained for the Nation by promoting industrially and socially profitable secondary applications of already-paid-for new aerospace technology.

b. Was NASA's new policy, introduced in 1966, of requiring actual-cost studies to be made by each RDC and the establishment of fee schedules for clients based on the findings of these studies, realistic in attaining the principal long-range goal of RDC performance, namely, bringing about general secondary application of new aerospace technology by intensive personalized work in the field?

c. Would selection of some middle ground between gratuitous and actual-cost services, which would have required for some time continuing subsidization of RDC activity, have been a reasonable step to have been taken in 1966?

The following tabulations of the client lists of NASA's RDC's should be considered in terms of these circumstances.

A second complication is that complete records of ad hoc clients are not readily available except for the end of 1969.

With these limitations, the following tabulation shows the relative success of the several RDC's in obtaining annual clients and, through the services performed for them, promoting acceptance of technology utilization as a practicable and valuable contribution to continuing industrialization. The data are as of the end of each calendar year:

	1963	1964	1965	1966	1967	1968	1969
ARAC	29	34	48	52	71	74	109
NC STRC				34	31	31	39
KASC		17	47	57	55	40	56
TAC				23	22	27	28
WESRAC					27	40	48
NERAC					0	13	30
Totals	29	51	95	166	206	225	310[53]

Although the growth of the number of annual clients has been slow, it has been continuous over the years reported.

As noted, the number of ad hoc clients is available only for the end of 1969. The data are as follows:

	Ad Hoc Clients	Total Clients
ARAC	92	201
NC STRC	31	70
KASC	5	61
TAC	7	35
WESRAC	0	48
NERAC	18	48
Totals	153	463

It is apparent that, were information about ad hoc clients available, the number of total clients, year by year up to 1969, would be much greater than the first tabulation shows.

Turning to total industrial income (income received in payment for all services) of the RDC's, the following tabulation shows a roughly comparable growth curve:

Total Industrial Income of Currently-Active RDC's
by Years (in dollars)[54]

	1963	1964	1965	1966	1967	1968	1969	Total
ARAC	82,043	96,188	134,795	147,111	200,863	133,000	142,980	937,980
NC STRC				17,262	15,738	16,000	33,617	82,617
KASC		26,949	74,506	90,358	87,187	62,000	67,218	408,218
TAC				14,000	25,000	53,000	81,342	173,342
WESRAC					35,000	47,000	37,626	119,626
NERAC					12,000	58,900	99,827	170,727
Totals	82,043	123,137	210,301	268,731	375,788	369,900	462,610	1,892,510

Note that during the years 1964-1970[55] NASA has allotted some $9,097,000 for support of all its RDC's (including ASTRA and CAST and the quasi-RDC, TUSC) and the further fact that this amount represents approximately 33.1% of NASA appropriations for the over-all technology utilization program and some 0.029% of total NASA appropriations for R&D during 1964-1970. In comparison, the $1,892,510 produced by the currently-active RDC's is not negligible and, in terms of its growth rate, is promising for the future. Also, the amount thus expended for RDC support, judging by what the RDC's already have accomplished, certainly appears to have been a profitable investment of a very small portion of NASA's total expenditures for R&D during this period; this is especially true if, as mentioned before, the long-range results of the United States technology utilization program ultimately rival NASA's success in placing Americans on the Moon.

IV. CONCLUSIONS AND RECOMMENDATIONS

Thirty years ago the world was radically different from what it is today. Apart from the monstrous fact that the nations, great and small, were in the opening phases of the most destructive war of all history, much of which we now take for granted had not yet appeared; television, stereo, jet travel, atomic energy, global satellites, the exploration of space, high-speed computers, and massive R&D were still developments of the future and in many instances had been only dimly foreseen. On the other hand, international and regional competition for industrial leadership was a rule of the day; as the sought-for basis of economic prosperity, such competition dated back to the beginnings of industrialization in the eighteenth century and by 1940 was on a rising curve of intensity. Today, with the world polarized by social doctrine and political philosophy, industrial competition between the leading nation in each camp and among the nations on either side of the curtain is more than ever the potential determinant of the ultimate destiny of all. Accordingly, the United States, as the responsible leader of the Free World since the end of World War II, must explore every avenue that gives reasonable promise of continuance of its present industrial primacy. The exploration of every such avenue should be carefully planned rather than backed into by chance; furthermore, it must be conducted with full realization of the extraordinarily rapid acceleration of technical advancement that characterizes the present and probably will continue into the future.

Keeping in mind the continuing intensification of industrial competition, especially at the international level, the most promising resources of the present are the enormous store of new technology that has been produced by massive R&D and the high-speed computers by which the millions of reports identifying items of new technology, all of which have already been paid for, can be classified and retrieved for any imaginable secondary application. Viewed in this light, the prescience of the lawmakers of the 85th Congress who incorporated what became Sections 102.(c)(4), 102.(c)(8), and 203.(a) of Public Law 85-568 - the charter of the National Aeronautics and Space Administration - deserves respect and public gratitude. In 1961 these clauses were interpreted by NASA as opening a new avenue for the continuing advancement of American industrialization - an avenue that necessarily would have to be explored. In the original estimate of the situation, the exploration thus called for would determine the extent to which new technology developed for aerospace purposes could be made available for advantageous secondary application by American industry generally and in the public sector as well.

This decision having been made, two offices in NASA's expanding organization were charged with its implementation. One of these - the Technical Information Division of the Office of Business Administration - had been carried over from a similar office of the National Advisory Committee for Aeronautics and now was considerably expanded and given increased support. The other - the Industrial Applications unit of the Future Applications Division, Office of Applications - was newly created. In addition, Technology Utilization Officers were appointed in each of NASA's Research Centers, and the first of NASA's Regional Dissemination Centers - ASTRA - was established by contract with the Midwest Research Institute at Kansas City, Missouri. Each of these elements had definite functions to perform in support of what was definitely an experimental program of technology utilization. In April 1963 the two principal offices for this program in NASA Headquarters were brought together as the Scientific and Technical Information Division and the Technology Utilization Division of a single Office of Technology Utilization; this action reduced or eliminated difficulties that had been inherent in a more diffuse organization, and NASA's program of technology utilization began to move out of its experimental phase.

The strength of this novel program lay in the character and experience of the agency of which it was a part. Responsible for the development of space probes, satellites, vehicles for safe travel in space, and other aerospace systems, NASA quickly became an outstanding leader in advanced technology; accordingly, the greater part of its personnel, including those manning the technology utilization program, were conversant with the character and requirements of R&D, many of them at the most sophisticated levels of R&D. This situation gave NASA's Office of Technology Utilization great advantage in planning and mounting the activities required for effective technology transfer, an advantage that was approached only by the Atomic Energy Commission among all the other Federal Agencies. Today, as a result of this Office's efforts, technology utilization, defined as both technology transfer and the stimulation of industrial R&D to advance at an accelerated rate, has been demonstrated as both practicable and of increasing value.

The conclusions stated above are essential to any analysis and evaluation of the part played by the Regional Dissemination Centers in NASA's over-all program. Turning to these RDC's, several general statements must be made for the record:

Conclusions and Recommendations

a. All eight of the full-fledged RDC's, beginning with ASTRA, must be regarded as major active participants in the development of NASA's technology utilization program. Introduced as a result of the realization that technology utilization, if it were to be successful, would require wide acceptance by both industrial firms and the public sector, they have been the TU field agencies whose face-to-face contacts and working relationships with management and staffs in each of their regions were designed to create an increasing national demand for technology transfer. As field agencies established for this purpose, they were also called upon to develop effective procedures, both promotional and operational, to attain their goal; the first ones to go into operation were very much on their own, without precedents to rely upon in what was truly an experimental operation. Furthermore, over the decade of their activity to date they have received slightly less than one-third of funds allocated by NASA for its technology utilization program. Again, when in 1966 the RDC's were informed that they should become financially self-supporting within a more-or-less definite period of years, no action was taken to increase their contract funds so as to make possible intensification of their marketing efforts. In this connection it should be noted that from the beginning NASA contractors and subcontractors (representing a sizable proportion of the R&D enterprises of the country) were furnished at no cost with Flash Sheets, Tech Briefs, and searches conducted by STIF; in many instances, it would appear, this policy not only deprived RDC's of possible clients but also impaired to some extent their efforts to promote acceptability of the concept of technology transfer.

b. The RDC' s as a group have made major contributions to NASA's technology utilization program. Listed in Part III of this study, they fall into three categories:

> Selection by experimentation and experience of the techniques most effective for winning attention for the concept of technology transfer and for obtaining and holding clients. During this first decade of the TU program, it would appear that, in the long run, the first of these - winning attention for the concept - has outranked the second in importance.
>
> Development and refinement of several major types of search service, designing maximum-economy search techniques, developing reliable procedures for providing productive personalized services to clients, and extending the information base available to every one of the RDC's to include, by either computer or manual search, all major sources of new technology. This last action, which goes beyond the original intent of NASA's TU program, was forced upon the RDC's by the logic of technology utilization requirements.
>
> Participation of most of the university-based RDC's in urging and assisting in the development and offering of degree courses in various aspects of technology utilization, thereby laying firm foundations for both increased understanding of the overall program and the preparation of individuals to take part in the future development. In addition, the RDC's have used both faculty members and graduate students in various part-time capacities, thereby increasing the number of individuals experienced in TU work and therefore probable proponents of the program.

c. An attempt to evaluate the performance of the RDC's by counting the number of validated technology transfers they have brought about represents, in our opinion, a misunderstanding of their principal functions during the initial decade of NASA's technology utilization program. To be sure, documented instances of technology transfer are facts and therefore can be counted as a basis for determining performance. It is also true, however, that the relationships that the RDC's established and the influences that they exerted - relationships with industrial firms and economic development agencies and promotion of the concept of technology utilization - also are facts to be reckoned with, even though they are not readily amenable to quantification.

d. Accordingly, after detailed study and analysis of the RDC's during the first decade of NASA's technology utilization program and keeping in mind their inability to date to attain financial self-sufficiency, we conclude that as a group they have quite satisfactorily performed the functions that NASA had in mind for them when the establishment of ASTRA was authorized. This does not mean that some individual RDC's have not been somewhat deficient, in comparison with some of their colleagues, in meeting certain of their responsibilities, nor does it imply that no changes in the requirements they must meet in the future should be made.

These being the conclusions reached by this study of NASA's Regional Dissemination Centers, recommendations regarding the RDC program are in order. Inasmuch as this program is an integral part of NASA's over-all technology utilization program, certain of these recommendations relate to the latter as well. The recommendations are as follows:

a. That NASA's contractual arrangement with each RDC be modified as follows to make possible expanded coverage within each RDC's region (or, alternatively, by establishing additional RDC's for this purpose), to compensate for the provision of TU services at no cost to NASA contractors and subcontractors, and to assist in obtaining the quality of staff personnel needed for improved performance of RDC functions, namely:

(1) Increase of contract support by an amount to be determined by a study made of each RDC, the objectives of which would be (a) the expansion of coverage deemed possible and desirable, such expansion to be phased in 3-year periods, and determination of the phased costs thereof; (b) reduction of fees charged annual and ad hoc clients by a percentage found to be necessary in order to put RDC clients who are not NASA contractors or subcontractors in a more favorable position vis-a-vis NASA contractors and

subcontractors, and determination of the costs thereof; and (c) to provide services, if found desirable, to small businesses at proportionately lower charges, and to determine the costs thereof.

(2) Changing the contract period for each RDC from one to three years, with each contract to be renewed for one year at the end of each year of the contract, all subject to performance by the contractor, in order to provide for increased stability of operations, to ensure the quality of permanent personnel, and to reduce the time now necessarily devoted to preparation of annual proposals, this to be done after successive annual reviews by the Technology Utilization Division of each RDC's performance to date and the Division's statement to each RDC of general guidelines for its continuing progress.

(3) Studies of the roles of the BATeams and TATeams and their possible relationships to the RDC's are also needed.

This particular recommendation is based on two assumptions, namely, that NASA views the technology utilization program as being of major national importance (as the evidence to date indicates), and that NASA regards the role of the RDC's as being essential to the program's success. As increasing emphasis is put on technology transfer to benefit the public sector, action along the lines here recommended becomes increasingly important.

b. That, in order to obtain more definite information about the results attained to date by the RDC's for use in increasing their effectiveness, the following action be taken:

On the basis of a complete listing of all clients, annual and ad hoc as well, served by all RDC's since 1 January 1966, a study be made by personal interviews of management and engineering personnel of 10% of such client firms, randomly selected, to ascertain in depth

(1) their identification of such technology transfers as have resulted from RDC services;

(2) their estimate of the extent to which RDC services have stimulated their own R&D work, with specific information as to the character of such stimulation;

(3) their general evaluation of the RDC services they have received; and

(4) their suggestions for improvement and/or expansion of these services.

The study should include classification of clients

(1) as annual and ad hoc;

(2) as home offices (or plants) of large firms, divisions of large firms, medium-size firms, and small firms;

(3) as to type of organizational structure and resources; and

(4) as to type of industrial production.

On the basis of these criteria, the findings from the interviews would be analyzed.

Although such a study would be essentially a market-analysis investigation, it would also provide valuable information as to the impact, in addition to actual technology transfers, that RDC services have had and, at the same time, would produce useful suggestions for refinement and expansion of those services.

FOOTNOTES

Part I

1 Phyllis Deane, The First Industrial Revolution, Cambridge, Cambridge University Press, 1965, p. 1.

2 Central Advisory Council for Science and Technology, Great Britain, Technical Innovation in Great Britain, London, HMSO, 1968, p. 1.

3 Although the General Electric Research Laboratories at Schenectady were a lineal outgrowth of the research laboratory that Elihu Thomson established at Lynn, Massachusetts, for the Thomson-Houston Company in 1882 (Thomson-Houston merged with the Edison General Electric Company in 1892 to form the General Electric Company), their opening in 1900, by virtue of the leadership they provided in this relatively new field, initiated the current trend of industry's dependence on industrial research.

4 In 1928, for example, the Bell Telephone Laboratories, established in New York City in 1925, were the largest industrial research organization in the world. They employed some 2,000 scientists and engineers for original research and development work in the field of electrical communications.

5 W. A. Hamor, "Research, Industrial· United States," Encyclopaedia Britannica, 14th ed, XIX, 206-207. The large industrial corporations, other than GE and AT&T, that maintained major industrial laboratories in 1928 were as follows:

E. I. duPont de Nemours & Company, Wilmington, Del
Eastman Kodak Company, Rochester, NY
Thomas A. Edison, Orange, NJ
General Motors Corporation, Detroit, Mich
B. F. Goodrich Company, Akron, O
Goodyear Tire & Rubber Company, Akron, O
International Harvester Company of America, Chicago, Ill
New York Edison Company, New York, NY
National Carbon Company, Cleveland, O
United States Rubber Company, New York and Detroit
Westinghouse Lamp Company, Bloomfield, NJ

6 Mervin J. Kelly, "The Bell Telephone Laboratories: An Example of an Institute of Creative Technology," Proceedings of the Royal Society, A, CCIII (1950), 287-288.

7 NSF, Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1968, 1969, and 1970, Washington, GPO, 1969, p. 3.

Footnotes

8 Estimate of the National Science Foundation, 8 April 1970.

9 According to one estimate, upwards of 5,000,000 scientific and technical reports and articles are published annually in some 100,000 journals throughout the world.

10 Los Angeles Times, 10 March 1970. The dollar value of computing machines, exclusive of the software they consume, has increased commensurately, from $350,000,000 in 1950 to $1,324,000,000 in 1960 to $4,156,000,000 in 1966. - Statistical Abstract of the United States, successive editions. Note also the comment of the British Central Advisory Council for Science and Technology, quoted on pp. 2-3, above.

11 Ibid.

Part II

1 PL 85-568, National Aeronautics and Space Act of 1958, 29 July 1958, sections 203.(a), 102.(c)(4), and 102.(c)(8).

2 Samuel I. Doctors' statement that the technology utilization program developed in response to this interpretation "was not established as an agency focal point for scientific and technical transfer, but to justify, in part, large NASA expenditures" (The Role of Federal Agencies in Technology Transfer, Cambridge, MIT Press, 1969, p. 68) does not take into consideration the situation as it was in 1958-1961. The requirements stipulated by the two sections of NASA's statutory charter referred to above were definite, if not precise. In particular, the demand for dissemination of information represented continuation of the National Advisory Committee for Aeronautics' long-established practice of publishing and disseminating Technical Reports, Technical Notes, Technical Memoranda, Aircraft Circulars, and Research Memoranda, together with Technical Publication Announcements, Accession Lists, and annual Indexes to NACA Technical Publications (J. C. Hunsaker, Forty Years of Aeronautical Research, Washington, Smithsonian Institution, 1956, pp. 259-260, and Robert E. Sauter, A Review of NASA's New Scientific and Technical Information Program, Washington, NASA, 1963, p. 1). By 1961 the quantity of scientific and technical reports and papers produced by NASA's laboratories and contractors was rapidly becoming unmanageable by existing means and, based on the experiences of NACA, the question was raised whether the mere distribution of reports on new technology, without screening and other additional services, was effective for the purposes for which it was intended. Careful reading of the minutes of the House Committee on Science and Astronautics' hearings on successive NASA Appropriations Bills, 1962 through 1969, shows that none of the Agency's principals (Webb, Dryden, Seamans, Newell) emphasized NASA's technology utilization program beyond describing its character and reporting progress. The NASA officials directly responsible for the program did support it enthusiastically, as would be expected of them when called upon to justify their budget requests; also the Committee's members showed keen interest in the program's potential value to the Nation. If the idea of immediate results on a grand scale from the

Footnotes

program was thus created, it could and probably did represent anticipation of earlier results across the board than the over-all complexity of developing a technology utilization program would permit. Further, as Doctors points out (op. cit., p. 69), the President's Science Advisory Committee's report, Science, Government, and Information, Washington, GPO, 1963, concluded that NASA had accepted responsibility for information activities that were relevant to its missions (Doctors, op cit., p. 70). Finally, at the Oakland Conference on Space, Science, and Urban Life in March 1963, Webb said that "We in the Space Agency do not seek to justify our program on the basis of the industrial applications which will flow from it. . . . since we are committed to this great effort in space, however, a responsibility exists to glean from it the maximum public benefits which can be obtained." (quoted in Richard S. Rosenbloom, Technology Transfer - Process and Policy, Washington, National Planning Association, 1965); again, in an article published in 1964, he wrote that "a clear directive from Congress and the President sets NASA the objective of extracting knowledge from its scientific and technological program and making this knowledge available to the maximum extent for the nation's industrial development." ("Commercial Use of Space Research and Technology," Astronautics and Aeronautics, June 1964, p. 74).

3. NASA Organization Chart, 29 January 1959, in Robert L. Rosholt, An Administrative History of NASA, 1959-1963 (NASA SP-4101, Washington, GPO, 1966.

4. Rosholt, op. cit., pp. 221, 259.

5 NASA Organization Chart, 26 April 1963, in Rosholt, op. cit.

6 See George J. Howick and James E. Mahoney, "Technology a Resource," Research/Development, September 1966, pp. 20-21.

7 Among the several types of evidence that support this statement is a list of articles, papers, reports, and books published in English during 1960-1963, inclusive, on the subject of technology transfer. One hundred sixty such references have been identified that deal with this subject, in whole or in part; they demonstrate a definite and increasing interest in this novel but very practical field.

8 NASA Contract NASr-63(03), for the period November 1961 - November 1962. This was a follow-on of an earlier contract, NASr-63(01), with Midwest for the period September 1961 - August 1962 which, although directed principally toward stimulating the universities and industries of these states to take a more active part in the space program, in effect called for a feasibility study for TU in this region.

9 ASTRA, Quarterly Progress Report No. 1, 5 November 1961 - 5 February 1962, p. 3.

10 For a checklist of the changes in title and location of the NASA Headquarters offices responsible for the over-all program of technology utilization, see Appendix A.

Footnotes

11 NASA, Sixth Semiannual Report to Congress, July 1 - December 31, 1961, p. 158.

12 NASA, Seventh Semiannual Report to Congress, January 1 - June 30, 1962, p. 130.

13 Paul C. Constant, Jr., Operation of a NASA Technology Utilization Regional Dissemination Center: Final Report, Kansas City, Midwest Research Institute, n.d., I, 11-13.

14 NASA, Seventh Semiannual Report, pp. 129-130.

15 Rosenbloom, op. cit., p. 24.

15 John G. Welles and others, The Commercial Application of Missile - Space Technology, Denver, Denver Research Institute, 1963.

17 NASA Contract NASr-162, for the period 15 December 1962 - 15 December 1963.

18 Joseph DiSalvo, ARAC Final Five-Year Report, Bloomington 1968. p. 7.

19 NASA, Eighth Semiannual Report to Congress, July 1 - December 31, 1962, p. 157.

20 NASA, Ninth Semiannual Report to Congress, January 1 - June 30, 1963, p. 152.

21 DiSalvo, loc. cit.

22 NASA, Eleventh Semiannual Report to Congress, January 1 - June 30, 1964, p. 168.

23 These organizations were Battelle Memorial Institute, Illinois Institute of Technology Research Institute, Arthur D. Little, Inc, Midwest Research Institute, Southern Research Institute, Southwest Research Institute, and Stanford Research Institute. - NASA, Ninth Semiannual Report, p. 162.

24 NASA, Tenth Semiannual Report to Congress, July 1 - December 31, 1963, p. 195; idem, Thirteenth Semiannual Report to Congress, January 1 - June 30, 1965, p. 180.

25 NASA, Tenth Semiannual Report, p. 195.

26 NASA Contract NASr-175, for the period January through December 1964. Supplemented by additional contracts through June 1968, CAST's operation as a NASA-supported RDC was terminated at the end of fiscal year 1968; however, by funds from local sources, CAST continues to function on a reduced basis.

27 NASA Contract NASr-235, for the period May 1964 through April 1965.

Footnotes

28 NASA Contract NASr-234, for the period May 1964 through April 1965.

29 NASA Contract NSR-32-004-013, for the period March 1965 through February 1966.

30 NASA Contract NSR-05-018-058, for the period March 1966 through September 1966, was for a study to determine the feasibility of an RDC at Los Angeles. WESRAC's operations began with NASA Contract NSR-05-018-071, for the period 15 October 1966 through 15 October 1967.

31 NASA Contract NSR-07-002-015, for the period June 1966 through April 1967, was also for a feasibility study for an RDC. NERAC's operations began with NASA Contract NSR-07-002-029, for the period April 1967 through March 1968.

32 Of the eight full-fledged Regional Dissemination Centers so established, two - ASTRA, in Kansas City, and CAST, in Detroit - were closed as NASA RDC's in October 1968 and June 1968, respectively. See Appendix B, Contract Chronology for NASA Regional Dissemination Centers, for summary data for all NASA RDC's.

33 NASA Contract NASr-178, for the period February 1964 through January 1965.

34 NASA, Eleventh Semiannual Report, p. 191.

35 1967 House NASA Authorization Hearings, IV, 638-639.

36 Constant, op. cit., I, 26.

37 NASA, Fifteenth Semiannual Report to Congress, January 1 - June 30, 1966, p. 167; idem, Sixteenth Semiannual Report to Congress, July 1 - December 31, 1966, p. 194.

38 NASA, Fifteenth Semiannual Report, p. 139.

39 NASA, Sixteenth Semiannual Report, p. 193; idem, Seventeenth Semiannual Report to Congress, January 1 - June 30, 1967, pp. 152-153.

40 NASA, Sixteenth Semiannual Report, pp. 193-194; idem, Eighteenth Semiannual Report to Congress, July 1 - December 31, 1967, p. 152.

41 WESRAC, Annual Report for the Period Ending February 1, 1968, p. 34.

42 See p. 13, above.

43 NASA, Eighteenth Semiannual Report, pp. 150-151.

44 KASC, Third Annual Report, May 1967, p. 3.

45 NC STRC, Final Report on a Regional Technology Transfer Program, April 1, 1967 - May 30, 1968, Research Triangle Park, 30 June 1968, p. 15.

Footnotes

46 See Appendix C, Magnetic Tapes and Abstracting and Indexing Journals for Specific Fields, 1962-date.

47 Research Triangle Institute, Technology Application Team Program: Applications of Aerospace Technology in Air Pollution Control, Quarterly Report 1, June-September 1969, pp. 2-3.

48 NASA, The NASA Scientific and Technical Information System, n.d., p. 14.

49 See Appendix D, Statements Regarding the Role of Personalized Services in Technology Utilization.

50 See, for example, Robert S. Jones, Consultant to CAST, Report on Termination of the Center for Application of Sciences and Technology as a National Aeronautics and Space Administration Supported Regional Dissemination Center, Detroit, 1968, p. 21.

51 See Appendix C for indication of the magnitude of these actions.

52 The annual value of computing machine shipments, including cash registers, for given years between 1947 and 1966, is given by successive editions of the Statistical Abstract of the United States as follows:

1947	$302,000,000
1950	$350,000,000
1955	$582,000,000
1960	$1,324,000,000
1963	$1,826,000,000
1965	$2,772,000,000
1966	$4,156,000,000

Also to be noted is Zbigniew Brzezinski's statement that "the United States has something like 60,000 computers in use in its economy while the Soviet Union has probably no more than 3,000." - U.S. News & World Report, 20 April 1970, p. 20. Furthermore, in a recent speech by Leonid Brezhnev, General Secretary of the Central Committee of the Communist Party of the USSR, Brezhnev is reported to have stressed Russia's need for more scientific and technical innovations. - Washington Post, 14 April 1970.

53 Senate Committee on Aeronautical and Space Sciences, Hearing on Space Program Benefits, 6 April 1970, pp. 10-11: testimony of Thomas O. Paine, Administrator, NASA.

54 See, for example, Joseph Ben-David, Fundamental Research and the Universities: Some Comments on Regional Differences, Paris, OECD, 1968, pp. 55-59, and Central Advisory Council for Science and Technology, Great Britain, op. cit., pp. 3-4.

55 Senate Committee on Aeronautical and Space Sciences, Hearing on Space Program Benefits, 6 April 1970, p. 36: testimony of Thomas O. Paine, Administrator, NASA.

Footnotes

56 This statement holds only since the Federal Government's withdrawal of funds to support the State Technical Services program in late 1969.

57 On this point, see again Appendix D.

58 1968 House NASA Authorization Hearings, I, 278.

59 Ibid., I, 277.

60 International Tin Research and Development Council, Great Britain, Historic Tinned Foods, ed 2, n.d., Greenford, Middlesex, England; Nelson H. Budd, "Canning: How It All Began," Good Packaging, XXI, January 1960, pp. 26-29.

Part III

1 In support of this point, M. Terry Sovel, University of Denver, Technology Transfer - A Selected Bibliography (NASA CR-1355), Washington, 1969, which is a highly selective but rather incomplete listing of such publications up to early 1969, records the following number of publications per year since 1963:

1964	30
1965	59
1966	69
1967	104
1968	73 (incomplete)
1969	19 (very incomplete)

2 As regards newspaper articles, Paul G. Steiger, "Computer Breeds New-Type Librarian: 'Information Scientist' Steers Industry to Fruits of Research Boom," Los Angeles Times, 5 October 1969, and A. Richard Immel, "Space Fallout: Data Banks Containing NASA Research Fruits Help Many Companies: Results of $35 Billion Effort Available at a Low Cost; Lockheed, Litton Use Files: Building a Better Oscilloscope," Wall Street Journal, 27 March 1970, are typical of one type of the literally thousands of reports that have appeared in all parts of the country.

3 For example, a Flat Cable Seminar was held 22-26 January 1968 at the University of Alabama Research Institute at Huntsville, Alabama, and a Workshop on Neutron Radiography, cosponsored by NASA, AEC, and SBA, at Pleasanton, California, 18 July 1969.

4 Thomas O. Paine, Administrator, NASA, Prepared Statement Submitted to the Senate Committee on Aeronautical and Space Sciences, 6 April 1970, p. 41.

5 Five of the six RDC's that are currently operational are university-based; the exception is NC STRC, which is an agency of the State of North Carolina, organized as a subsidiary of the North Carolina Board of Science and Technology.

Footnotes

6 The Directors of the RDC's now operational report as follows:

ARAC	Chairman of the Indiana University Foundation
NC STRC	Governor of the State of North Carolina in his capacity as the Chairman of the North Carolina Board of Science and Technology
KASC	Director of Communications Programs, University of Pittsburgh
TAC	Deputy Director of the Institute for Social Research and Development, University of New Mexico
WESRAC	Director of the Research Institute for Business and Economics, Graduate School of Business Administration, University of Southern California
NERAC	Dean, School of Business Administration, University of Connecticut.

7 For some of the RDC's, this last function (accounting services) is performed by a business manager who is not part of the technical operations group.

8. KASC, for example, uses the part-time services of engineering faculty, whereas WESRAC relies principally on graduate students in engineering or business administration.

9 ASTRA, organized at the Midwest Research Institute at Kansas City at the same time the original Industrial Applications unit was created in NASA Headquarters, was the first RDC to go into operation. NASA's pioneer field agency for technology utilization, it functioned for seven full years, contributing greatly to the technology utilization field program.

10 Midwest Research Institute, ASTRA, Kansas City, n.d., p. 11.

11 ARAC Operating Manual, Describing ARAC Services to Member Companies, ed 6, Bloomington, 1967, pp. 4-6.

12 Paul C. Constant, Jr., Operation of a NASA Technology Utilization Regional Dissemination Center: Final Report, Kansas City, Midwest Research Institute, n.d., I, 43.

13 Ibid., I, 21, 38.

14 Technology Utilization Division, NASA, Regional Dissemination Centers [mimeographed summary], 1 January 1970.

15 Denver Research Institute, The Environment and the Action in Technology Transfer, 1970-1980, Denver, n.d., p. 10.

16 Ibid., p. 20.

17 Not all of the RDC's have relied principally on the conference method, which ARAC introduced and employed quite effectively. Direct mail solicitation and newspaper, trade journal, radio, and TV advertising have been employed to a greater or less extent, depending on the RDC, together with careful searches of available industrial directories.

Footnotes

18 Semimonthly, monthly, or bimonthly, as determined by the individual RDC or, when standard interest profiles are employed, by current activity in the field being searched.

19 Skillful preparation of computer instructions is most important. At one time, for example, the combined STAR-IAA bank contained 790 reports indexed under "high altitude" and 1,092 under "bearing," but only 7 indexed under both terms. To save computer time (and therefore money) in a search involving "high altitude bearing," it was necessary, in the instructions to the computer, to list the two terms in their proper order and properly linked.

20 Ralph H. Sprague, Jr., A Comparison of Systems for Selectively Disseminating Information, Indiana University, 1965.

21 Charles W. Mullis, Associate Director, ARAC, "Some Techniques for Automatic Searching of Government Report Literature," paper presented at 22nd Annual Conference, Instrument Society of America, Chicago, 14 September 1967.

22 Since the RDC's have obtained the magnetic tapes for other data banks (see Appendix C), it is possible to augment the NASA base by one or more searches of other materials. This involves additional costs to the client and so requires his agreement.

23 M. Terry Sovel and Dean C. Coddington, A User's Evaluation of a NASA Regional Dissemination Center, Denver, May 1969, pp. 5-6.

24 KASC, Searching the Texts of Document Surrogates: An Empirical Test of Usefulness, Pittsburgh, n.d.

25 According to the current (1970) numbering system for SIP's; ARAC's original issue of SIP's consisted only of 32.

26 Joseph DiSalvo and Robert W. Hall, ARAC, Final Report, Standard Interest Profiles: Development of Technical Subjects, Bloomington, February 1968, p. 4. Appendix I of this report lists the SIP's for which by the end of January 1968 ARAC had received fifteen or more subscriptions, as follows:

Semiconductor Devices and Microcircuit Fabrication	21
Materials Joining Technology	17
Corrosion and Protective Coatings	17
Material Forming and Machining	16
Bearings and Lubricants	15
Display Systems	15

27 In January 1968 ARAC began to charge for the hard copies of reports whose abstracts appeared in SIP packages.

28 ARAC, Quarterly Report, First Quarter 1969, Bloomington, 10 June 1969, p. 30.

29 Expansion of the information base necessarily has affected an RDC's

Footnotes

charges. For example, for a retrospective search of the STAR/IAA file only, NC STRC charges annual clients $60; for a search covering the STAR/IAA and DOD files, $100; and for a search covering the STAR/IAA, DOD, and ITT files, $125. In this connection, most of the RDC's leave it to the engineer planning a search to decide what files shall be processed.

30 Charles Murray and Lem M. Kelly, NC STRC, Detailed Study of the Potential Market of the Southeastern States, Research Triangle Park, February 1969.

31 Technology Utilization Division, NASA, Regional Dissemination Centers, 1 January 1970.

32 WESRAC, Annual Report for Period Ending February 1, 1968, Los Angeles, February 1968, p. 18.

33 Technology Utilization Division, NASA, op. cit.

34 Constant, op. cit., I, 17.

35 Technology Utilization Division, NASA, op. cit.

36 Ibid.

37 On this point, information as to the annual value of industrial production (that is, the annual value accredited to manufacture) in the states of the United States is significant. The six states in which RDC's are located and which have 48% of all RDC clients accounted for $65,116,000,000 of the total of 1967's GNP attributable to manufacture, which was 25.1% of the national total created by manufacture; the detail is as follows:

Indiana	$10,071,000,000
North Carolina	$6,377,000,000
Pennsylvania	$18,864,000,000
New Mexico	$171,000,000
California	$23,123,000,000
Connecticut	$6,510,000,000

On the other hand, the twenty states that have no clients of any RDC reported for 1967 as follows; they accounted for $35,886,000,000 or 13.8% of this increment of the GNP for that year:

Alabama	$3,661,000,000
Alaska	$126,000,000
Arkansas	$1,568,000,000
Georgia	$5,034,000,000
Hawaii	$330,000,000
Idaho	$505,000,000
Iowa	$3,227,000,000
Kansas	$2,011,000,000
Louisiana	$2,728,000,000
Maine	$1,021,000,000

Footnotes

Mississippi	$1,656,000,000
Montana	$315,000,000
Nebraska	$1,138,000,000
North Dakota	$117,000,000
Rhode Island	$1,357,000,000
South Dakota	$172,000,000
Vermont	$486,000,000
Washington	$3,276,000,000
Wisconsin	$7,062,000,000
Wyoming	$96,000,000

It goes without saying that these data are the latest available. - Statistical Abstract of the United States, 1969, pp. 722-723.

38 The historical record shows that, beginning about the third decade of the nineteenth century, the navies of the then Great Powers demanded increasing mechanization and constant improvement in all areas of naval technology. As a result, long before the now-familiar terms of research and development came into use, a growing tradition of R&D was established in each major admiralty. Naval architects and designers and the men responsible for naval ordnance worked out quite clearly defined procedures for acquiring and utilizing the scientific and technical information they needed for solving their problems. Nevertheless, despite the enormous pressures exerted by international rivalry, progress was relatively slow. In 1827, for example, the British Admiralty conducted the first experimental test of solid cast-iron shot fired against bar armor, thus initiating the systematic testing of naval armament. In 1871 the British Admiralty tested the 14" wrought-iron armor to be used on HMS Dreadnought; this was the last major test of iron armor, for in 1876 the Italian Navy, by the first significant tests of steel armor, opened a new and more promising field of armor development. Thereafter, attention was directed toward comparison of compound (wrought iron plate with a backing of rubber or cork) and steel armor, which eventually proved the latter to be superior. In interpreting this record, it should be noted that wrought iron plate was introduced in 1834; both laminated (riveted layers of wrought iron plate) and composite armor were first available in 1840; and cast-steel armor was first tried out, with promising results, in 1856. Thus, despite the early origins of R&D in the admiralties of the Great Powers, the great pressures exerted by international competition for naval strength, and the relatively early dates at which new types of armor were available, heavy industry, even when guided by powerful government agencies and recognizing opportunities for large profits, exhibited the inertia in this field of armament development that is referred to in the text above. Many other examples are cited in John Jewkes, David Sawers, and Richard Stillerman, The Sources of Invention (New York, St. Martin's Press, 1959).

39 Donald N. Smith, Assistant Director, Industrial Development Division, Institute of Science and Technology, University of Michigan, "Why Companies Balk at Technology Transfers," Columbia Journal of World Business, II, May-June 1967, pp. 45-53.

40 Ibid.

Footnotes

41 In 1966 NASA's Office of Industrial Applications found that nearly eight times as much interest on the part of large as well as small companies in applying aerospace technology was motivated by the possibility of improving an existing product or process as was motivated by the chance of adding a completely new item to a firm's line. - Philip Wright, "Technology Transfer and Utilization - Active Promotion or Passive Dissemination?" Research/-Development, XVII, September 1966, p. 36. To be sure, this finding dates from an early period of RDC operations.

42 NERAC, Final Report for the Period 1 April 1967 to 31 March 1968, Storrs, March 1968, pp. 23-24.

43 WESRAC, Annual Report for Period Ending February 1, 1968, pp. 36-37.

44 See Appendixes E, F, and G. Appendix E shows that during the 7-year period, 1964-1970 inclusive (the only years for which firm allocations for over-all technology utilization as now regarded can be identified), 33.1% of all TU funds were expended directly for NASA's RDC's; this percentage does not include such overhead charges as could be debited to the RDC program, such as those for Technology Utilization Division activities and the services provided the RDC's (magnetic tapes, microfiche, etc) by the Office of Technology Utilization. Even so, it indicates the importance attached to the RDC program in NASA Headquarters' judgment. Appendixes F and G present more detailed breakdowns of NASA allocations to the RDC's.

45 In the first operational quarter, February - April 1962, ARAC held five half-day meetings in cities in Iowa, Kansas, Missouri, and Oklahoma to introduce its technology utilization program to industrial and regional leaders. These meetings were attended by individuals representing 241 industrial firms and 106 organizations concerned with economic development. Each meeting was reported in the local newspapers, as witness, for example, articles in the Oklahoma City Times of 13, 14, and 23 March 1962. In addition, during this same period ASTRA made other presentations to the Economic Club of Oklahoma, the annual meetings of the Missouri and the Kansas Bankers Associations, and the annual meeting of the Midwest Research Institute Trustees; these also produced newspaper reports and editorial comments. - ASTRA, Quarterly Progress Report No. 2, 5 February - 5 May 1962, Kansas City, February 1962, p. 2. This type of activity, with its accompanying news media coverage, was continued by ASTRA and duplicated to a greater or less extent by the other RDC's as each was established.

46 In 1968, for example, KASC reported that 89% of its search services for clients were of the current awareness type and that even some of the retrospective searches conducted were not of the problem-solving types. - KASC, Fourth Annual Report, Pittsburgh, June 1968, I, 3.

47 For example, in its Fifth Annual Report, June 1969, IV, 4, and Sixth Annual Report, April 1970, IV, 3, KASC states that it has placed major reliance on direct mailings for solicitation of interest in technology utilization and obtaining initial contact with potential clients. The reports of the other RDC's indicate that, although all use this technique, none of them depends on it to the extent that KASC does.

Footnotes

48 ASTRA, the first RDC to be established by NASA but no longer active, was especially outstanding in this respect.

49 It has not been verified that every one of the RDC's use this device.

50 Both NASA's Office of Technology Utilization and ACORDD have played a significant role, assisted by the individual RDC's, in having national newspapers and other national publications publish reports and articles describing the RDC's and their services. See, for example, the article in the 27 March 1970 issue of The Wall Street Journal and the entire issue of Research/Development for September 1966.

51 Here again it is not known whether all of the RDC's follow this practice.

52 All other expansions of the information base by acquisition of magnetic tapes (and this has been appreciable since 1967) resulted principally from actions taken by NASA Headquarters.

53 If the annual clients of ASTRA and CAST, which are no longer active as NASA RDC's, are added, the totals would be as follows:

1963	1964	1965	1966	1967	1968	1969
29	101	145	257	261	225	310

54 Inasmuch as total income by years is not readily available for ARAC, NC STRC, and KASC before 1968 (only total income for the periods prior to 1968 in which each RDC was active), estimates of each RDC's annual income for those years has been made by reference to the number of annual clients each had each year of operation. It is recognized that this method leaves ad hoc clients out of consideration, but this cannot be avoided because such data also are not available.

55 The figures for 1970 are to this time of writing. Also, the amounts allocated by NASA for technology utilization in 1962 and 1963 are not available.

Appendix A

Checklist of Titles and Locations

of NASA Headquarters Offices Responsible for Technology Utilization

Technology Utilization Division

Industrial Applications Unit, Future Applications Division, Office of Applications
November 1961 - November 1962

Industrial Applications Division, Office of Applications
November 1962 - April 1963

Office of Technology Utilization, Office of Technology Utilization and Policy Planning
April 1963 - December 1964

Technology Utilization Division, Office of Technology Utilization
December 1964 - date

Scientific and Technical Information Division

Technical Information Division, Office of Business Administration
October 1958 - May 1960

Technical Information Division, Office of Technical Information and Educational Programs
May 1960 - January 1962

Office of Scientific and Technical Information, Office of Public Affairs
January 1962 - April 1963

Office of Scientific and Technical Information, Office of Technology Utilization and Policy Planning
April 1963 - December 1964

Scientific and Technical Information Division, Office of Technology Utilization
December 1964 - date

CONTRACT CHRONOLOGY

ASTRA

NASr-63(03), with amendments, Nov 1961 - Oct 1967
Establishment and operation of ASTRA as an RDC

NASr-63(04), with amendments, Jan 1963 - Dec 1964
Special projects

NASr-63(12), with amendment, Mar 1967 - Oct 1968
Operation

ARAC

NASr-162, with amendments, Dec 1962 - Dec 1967
Establishment and operation of ARAC as an RDC

NSR-15-003-032, Feb 1966 - Jan 1967
Special projects

NSR-15-003-054, with amendment, Apr 1967 - May 1969
Special projects

NSR-15-003-055, Feb 1967 - Jan 1968
Special projects

NSR-15-003-061, Feb 1967 - Dec 1967
Special projects

NSR-15-003-076, Apr 1968 - Dec 1970
Operation and special projects

NASW-1942, Apr 1969 - Sep 1970
Special projects

CAST

NASr-175, with amendments, Jan 1964 - Jun 1968
Establishment and operation of CAST as an RDC

NSR-23-006-034, Jan 1966 - Dec 1966
Special projects

NSR-23-006-037, with amendment, Jul 1966 - Dec 1967
Special projects

NSR-23-006-041, with amendment, Jan 1967 - Jun 1968
Special projects

NSR-23-006-044, Jan 1967 - Dec 1967
Special projects

NSR-23-006-049, May 1967 - Apr 1968
Special projects

TUSC

NASr-178, with amendments, Feb 1964 - Nov 1967
Establishment and operation of TUSC as a quasi-RDC

NSR-37-004-006, with amendments, Sep 1966 - May 1968
Operation and special projects

NSR-37-004-008, with amendment, Apr 1968 - May 1969
Operation and special projects

NSR-37-004-009, May 1969 - May 1970
Operation and special projects

NC STRC

NASr-235, with amendments, May 1964 - Mar 1967
Establishment and operation of NC STRC as an RDC

NSR-34-007-003, with amendments, Apr 1967 - May 1968
Operation

NSR-34-007-005, with amendments, Apr 1967 - Jun 1968
Special projects

NSR-34-007-006, with amendments, Jun 1968 - Aug 1969
Operation and special projects

NASW-2051, Sep 1969 - Aug 1970
Operation

NASW-2050, Sep 1969 - Aug 1970
Special projects

KASC

NASr-234, with amendments, May 1964 - Feb 1967
Establishment and operation of KASC as an RDC

NSR-39-011-064, with amendments, Oct 1966 - Oct 1969
Special projects

NSR-39-011-070, with amendment, Feb 1967 - Feb 1968
Operation

NSR-39-011-076, with amendment, Jan 1968 - Sep 1969
Special projects

NSR-39-011-078, with amendments, Jul 1967 - Feb 1970
Special projects

NSR-39-011-089, Mar 1968 - Feb 1969
Operation

NSR-39-011-106, Mar 1969 - Feb 1970
Operation

NSR-39-011-105, Sep 1969 - Aug 1970
Special projects

TAC

NSR-32-004-013, with amendments, Mar 1965 - Sep 1967
Establishment and operation of TAC as an RDC, and special projects

NSR-32-004-037, Jul 1967 - Jun 1968
Operation

NSR-32-004-049, with amendment, Jul 1968 - Jun 1970
Operation and special projects

WESRAC

NSR-05-018-058, with amendments, Mar 1966 - Jan 1967
Feasibility study

NSR-05-018-071, with amendments, Oct 1966 - Feb 1968
Establishment and operation of WESRAC as an RDC

NSR-05-018-093, Feb 1968 - Jan 1969
Operation

NASW-1869, Jan 1969 - Jan 1970
Operation

NERAC

NSR-07-002-015, with amendments, Jun 1966 - Apr 1967
Feasibility study

NSR-07-002-029, with amendment, Apr 1967 - Mar 1968
Establishment and operation of NERAC as an RDC

NSR-07-002-037, with amendment, Apr 1968 - Sep 1969
Operation

NSR-07-002-048, Oct 1969 - Sep 1970
Operation

Appendix C

Magnetic Tapes and Abstracting and Indexing Journals for Specific Fields, 1962-date

The following magnetic tape services and abstracting journals have been obtained by one or more of NASA's Regional Dissemination Centers:

	Year Tape Began	Average Annual Abstracts
STAR, for Scientific & Technical Aerospace Reports	1962	26,000
IAA, for International Aerospace Abstracts	1963	26,000
MEDLARS, for Index Medicus[1]	1964	175,000
ERIC, for Research in Education	1964	3,800
DOD, for US Government R&D Reports	1964	17,000
ITT, for Textile Technology Digest	1966	11,000
EI Compendex, for Engineering Index	1968	20,000
CA Condensates, for Chemical Abstracts	1968	265,000
Chemical Titles[2]	1969	125,000
BA Previews, for Biological Abstracts	1969	220,000

1 Index Medicus is not an abstracting journal, but contains only citations of articles.

2 Tape only, based on key words in titles of articles published in 650 chemical journals.

Appendix D

Statements Regarding the Role of Personalized Services in Technology Utilization

"The second factor, which is of over-riding importance in the use of technical information to produce industrial innovation, is that of personal contact. Other channels of communication are essential; but without the addition of personal human contacts, they may be, and often are, of little value by themselves. If one lesson stands out above all others from a study of Scottish industrial development, it is that the failure of communications has derived very largely from a failure of human contacts.

"Such personal relationships are doubly necessary. They are essential if a proper perspective on the innumerable facts in any developing situation is to be obtained. There are plenty of examples to be found of the way in which a flow of paper, unaccompanied by adequate human movement, can produce ideas and proposals which are remote from reality. Second, personal contact is vital to the kindling of enthusiasm. Enthusiasm is no less important a factor in industrial innovation than knowledge. Again, the post-war history of Scotland provides many instances of the way in which sparks which are struck by personal contact can encourage manufacturers to strike off in fresh directions, making use of information which is readily available."

- W. S. Robertson, Chief Executive Officer, Scottish Council for Development and Industry, "Technical Information and Industrial Innovation," in Conference on Science and Industry, The Problem of Communication, London, 1962, p. 7.

"The T.U. program, so far, seems to have conveyed primarily 'incidental advances in technology' - relatively simple R&D results. But we believe that to bring about even simple R&D results, and to do so more effectively, the publications program must be supplemented with more active attempts at transfer, through personal contact, to establish a bridge from the NASA innovator to the potential end user, introducing what in industry would be called the "entrepreneurial approach" to new products development. . . .

"The method we have found successful involves direct contact with industrial management, thorough discussion of the relevance of new technology in the industrial context, and rapid follow-up of any expressed interest. This process of technology transfer cannot, however, be reduced to a set of instructions. . . .

"Based on our experience with this approach, we believe that far more meaningful transfer will take place as a result of it than through dissemination of written reports. In other words, we hold that NASA can produce many more instances of transfer through the entrepreneurial approach - an active transfer program - than it has through publication."

- A. D. Little, Inc. Technology Transfer and the Technology Utilization Program, Cambridge, 1965, pp. ix-x, 77.

"The objective of the regional dissemination activities of NASA is to establish close personal contact which we believe is essential if actual transfer and application of new technology to new uses is to take place."

- Breene M. Kerr, Assistant Administrator for Technology Utilization, NASA, 3 March 1965, in 1966 House NASA Authorization Hearings, IV, 99-100.

"It is also observed that there are two essential components of technology transfer. These are an automated information retrieval and dissemination system and a personal contact. The information pileup has become so great that information is essentially lost unless a selective dissemination system is perfected. In addition to the identification and location of information, there must be a personal contact between the source of information and the industrial user."

- Argonne Office of Industrial Cooperation, AEC, First Semiannual Report, 1 January - 30 June 1965, as cited in Richard L. Lesher and George G. Howick, Assessing Technology Transfer (NASA SP-5067), Washington, 1966, p. 60.

"The implications of a new technology in a variety of fields cannot be transferred by the written word. Some interplay between individuals is necessary to permit modification of the ideas of both the giver and the receiver in order to have a meshing of the proposals of each. Therefore, to increase the rate of technology utilization, a means must be provided to permit a meeting of qualified individuals. Publication is an important step in this process, but it is only the first step. Its primary purpose is to bring to the attention of the proper individuals the fact that certain information is available and to identify its source, thereby opening the way to subsequent communication between people with mutual interest. It is necessary to set up a system by which this can be accomplished and a special effort should be made to clarify the procedure to be followed."

- Committee Report to Oak Ridge Operations Office, AEC, Transference of Nonnuclear Technology to Industry, July 1965, as cited in ibid., p. 100.

"It is demonstrably evident that a critical point in the transfer and utilization mechanism is frequently the personal confrontation of the intended user with the innovator. Such a confrontation, if skillfully managed and responsibly contributed to by all parties, generates within the user that degree of enthusiasm which is psychologically necessary for embarking on a new endeavor characterized by educated guesses about immeasurable unknowns.

"Without such emotion, passivity on the part of small and medium-sized businesses is not surprising. If something could be injected at the passive point, it would surely have a revivifying effect leading to resolution of many of the cases we studied. . . ."

- Philip Wright, "Technology Transfer and Utilization: Active Promotion or Passive Dissemination, "Research/Development, September 1966, p. 35.

"It will surprise no one that the single most important factor in effective technology transfer is the personality of the TUSC field man. If he cannot effectively communicate with his client, the process of transfer never begins. When our field man makes his first call on a prospective client, he has done much preliminary work to familiarize himself with the client's problems. He takes along NASA literature with specific appeal to the client's interests. Many times, the potential client indicates virtually no interest during the first encounter. Then, surprisingly, he may call the next week asking for help in solving a specific problem. If that doesn't happen, the field man may find the next time he calls, a desire for assistance. Obviously, there is no real pattern in technology transfer."

- Lee B. Zink, "Technology Utilization in a Non-Urban Region," Research/Development, September 1966, p. 43.

"Regional Dissemination Centers frequently refer their clients to additional sources of information to supplement the information provided from NASA. One such case involved an Oklahoma company in need of a shroud material to connect a vibrating conveyor to an exhaust plenum in a glass products manufacturing operation. Materials being tried by the company were lasting less than three weeks. A Regional Dissemination Center, whose personnel were familiar with these types of materials, referred the company to a manufacturer of nylon cloth impregnated with a specialized fluorelastomer. The material was tested and found durable, saving the company $600 annually in replacement costs.

. . .

"A research director of a Pittsburgh company needed information on maintainability of certain high vacuum equipment. He had been seeking this information without success. At the invitation of the Regional Dissemination Center of which his firm is a member, he attended a Technology Utilization Conference at Lewis Research Center, where he heard a paper touching on the subject. He later contacted the NASA researcher who authorized the paper, visited with NASA Lewis Research Center personnel with experience in the area, obtained the desired information, and, as a result, his firm has proceeded with a capital investment program to build a capability for vacuum deposition of various kinds of thin films on steel substrates on a production basis."

- Richard L. Lesher, Assistant Administrator for Technology Utilization, NASA, 9 March 1967, in 1968 House NASA Authorization Hearings, I, 578, 580.

"In fact, I would go so far as to say that the entire process of technology transfer should be dealt with in terms of people.

"The problem of information retrieval and the transfer of documents is not the main issue at all. And it has been looked upon as the main issue in many quarters. Hundreds of technical reports sent to a person or an organization, neither capable of handling them nor interested in their interpretation and reduction to commercial purposes, is useless. Some hope has been expressed in the past that scientists and engineers working on Government-financed R&D programs could be induced to be more concerned with the possible implications of their work to industry or to other problems of a public nature. This has not been a fruitful source of transfer, largely because the type of person whose aspiration is to achieve scientific and technical progress for himself is generally not the type who also seeks to perfect technology transfer.

"Technical and management people in the private sector whose sole association has been with Federal R&D programs seldom possess the necessary attributes, insights, or viewpoints to develop products or processes for a highly competitive commercial market.

"The technology transfer process is social and economic in form and purpose, rather than scientific or technical. The decisions to use technology, particularly in industry, are economic decisions, rather than technical decisions. And, therefore, people who are concerned with transfer as their main profession need to be judged on a scale of accomplishment that is quite different from that employed to evaluate and reward conventional R&D persons.

"In order to stimulate, accelerate, and promote this transfer process through overt programs, circumstances must be provided to make it easier for individuals and companies to be innovators. We need demonstration that markets exist for new technology products, that the risk is reasonable, that the cost-benefit ratio is favorable, and that the competition in a given sector is not excessive. The more of this that is done by the transfer agent, the easier it will be for the ultimate user to become an innovator in his own right.

"The type of person I am describing here might be called an "applier of technology." He will have two outstanding personal characteristics, irrespective of where he works.

"First, he will understand the world in which commercial forces operate. And he will have some broad technical background. In fact, it might be more advisable and practical to select appropriate generalists, and supply them with the necessary technical facts, than it would be to attempt to convert a conventional scientist through exposure to economic reality or to the requirements of corporate management."

- Charles N. Kimball, President, Midwest Research Institute, 26 September 1967, in Senate Select Committee on Science and Technology. Hearings on Technology Transfer, p. 40.

"The basic philosophy of service changed during the latter part of the program to that of interpretive and adaptive handling of information for optimal benefit to the client. Moreover, the service sought to help the client more with specific problems, rather than to provide it with vast amounts of information. In addition, the User-Producer Conference was born. The consultation and telephone inquiry services were continued.

"The interpretive and adaptive handling of information was accomplished by interpretive and noninterpretive retrospective searching and interpretive and noninterpretive current awareness surveillance. The appropriate technical talents were directly associated with a problem from its definition (ASTRA working directly with the client), through preparation of search strategies, review of abstracts and documents, weighing relevance of information, and preparing summary reports for client. This system proved to be extremely valuable to the client, since the client was involved a minimum for a maximal return from NASA's bank of information. Consequently, the value to the client increased by orders of magnitude over previous services."

- Paul C. Constant, Jr, ASTRA, Operation of a NASA Technology Regional Dissemination Center: Final Report, Kansas City, Midwest Research Institute, n.d., I, 43.

"ARAC's most valuable asset is its excellent technical staff. . . .

"The special skill of the ARAC professional lies in his knowledge of the many information resources available to ARAC. His usefulness lies in being able to understand the problems of industry. . . .

"You can consider the ARAC professional as an extension of your own staff either for conducting a review of possible information sources when faced with a specific problem, or for keeping your staff informed about recent developments in areas of continuing interest. We encourage informal working relationships between our staff and the scientists and engineers in industry."

- ARAC, 1969 ARAC Services Catalog, Bloomington, 1969, p. 4.

"Our conference has confirmed what a lot of us have suspected, that something more is necessary for technology transfer to be effective. That something more is the personal element, communication between people. And to understand technology transfer better, we must shift our base to the demand side, the users. This should be the research strategy for the 1970's."

- Daniel L. Spencer, Chairman, Department of Economics, Howard University, speaking at a conference sponsored by Denver Research Institute at Snowmass-at-Aspen, Colorado, 26-28 September 1969 (cited in The Environment and the Action in Technology Transfer, 1970 - 1980, DRI, 1970, p. 20).

Appendix E

Comparison of NASA Total Obligations for R&D
with Allocations for Technology Utilization and Allocations for RDC's
(in Thousands of Dollars, by Fiscal Year)

FY	R&D	TU (% of R&D)		RDC's (% of TU)	
1962	1,439,200	not available		168	
1963	2,857,400	not available		334	
1964	4,286,600	3,192	(0.074)	808	(25.3)
1965	4,951,500	4,451	(0.090)	1,234	(27.7)
1966	5,050,000	3,453	(0.068)	1,298	(37.6)
1967	4,867,000	4,166	(0.086)	1,859	(44.6)
1968	4,429,400	4,320	(0.098)	1,631	(37.8)
1969	3,815,900*	3,939	(0.103)	1,182	(30.0)
1970	3,792,800*	4,000*	(0.105)	1,085*	(27.1)
1964-70	31,193,200[1]	27,521[2]	(0.088)	9,097[3]	(33.1)

* Estimated

1 National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities, XVIII, 249.

2 US Bureau of the Budget, Budget of the United States Government, Appendix (for successive years).

3 Compiled from NASA contracts

Appendix F

Summary of NASA Allocations to RDC's

(in Thousands of Dollars, by Fiscal Year)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
ASTRA	168	259	339	207	173	175	167			1488
ARAC		75	225	350	362	345	216	54	104	1731
CAST			150	300	300	278	161			1189
TUSC			52	107	103	98	77	76	71*	584
NC STRC			17	83	37	115	128	124	129	633
KASC			25	162	243	315	265	182	120*	1312
TAC				25	51	151	162	170	170	729
WESRAC					29	239	195	292	296*	1051
NERAC						143	260	284	195	882
Total	168	334	808	1234	1298	1859	1631	1182	1085	9599

* Estimated in part

Appendix G

Average Monthly Allocations by NASA to RDC's

(in Thousands of Dollars)

	Total Allocation	Months of Operation	Average Monthly Rate
ASTRA	1488	76	19.6
ARAC	1731	91	19.0
CAST	1189	54	22.0
TUSC	584	77	7.6
NC STRC	633	74	8.6
KASC	1312	74	17.7
TAC	729	64	11.4
WESRAC	1051	52	20.2
NERAC	882	48	18.4
Total Averages	1067	67.8	15.7

Appendix H

Comparative Performance of Currently-Active RDC's Based on

Value Added by Manufacture in Region of Each RDC in Calendar 1967

	Value Added by Manufacture[1]		Total Clients, 1969		RDC Industrial Income, 1969	
	(millions)	(% of total)	(number)	(% of total)	(dollars)	(% of total)
ARAC	$72,568	28.0	201	40.0	$142,606	30.9
NC STRC	$37,026	14.3	70	13.9	$33,708	7.3
KASC	$56,871	21.9	61	12.2	$67,178	14.5
TAC	$19,281	7.4	35	7.0	$81,214	17.6
WESRAC	$29,444	11.4	47	9.4	$37,386	8.1
NERAC	$44,111	17.0	88	17.5	$99,825	21.6
Totals	$259,301	100.0	502	100.0	$461,917	100.0

[1] Statistical Abstract of the United States, 1969, pp. 722-723.

Dollars of RDC Industrial Income

per Million Dollars Added by Manufacture

		Rank
ARAC	1.97	3
NC STRC	0.91	6
KASC	1.08	5
TAC	4.21	1
WESRAC	1.27	4
NERAC	2.26	2

Comparative Performance of Currently-Active RDC's Based on

Number of Scientists Employed in Region of Each RDC in Calendar 1968

	Scientists Employed[1]		Total Clients, 1969		RDC Industrial Income, 1969	
	(Number)	(% of total)	(Number)	(% of total)	(Dollars)	(% of total)
ARAC	55,236	18.9	201	40.0	$142,606	30.9
NC STRC	35,080	12.0	70	13.9	$33,708	7.3
KASC	64,912	22.2	61	12.2	$67,178	14.5
TAC	38,811	13.3	35	7.0	$81,214	17.6
WESRAC	45,849	15.7	47	9.4	$37,386	8.1
NERAC	52,397	17.9	88	17.5	$99,825	21.6
Totals	292,285	100.0	502	100.0	$461,917	100.0

[1] _Statistical Abstract of the United States, 1969_, p. 529.

Annual Clients of Each RDC

per Number of Scientists (x 10,000) Employed

		Rank
ARAC	36	1
NC STRC	20	2
KASC	9.4	5
TAC	9.0	6
WESRAC	10	4
NERAC	17	3

Average Rank of Currently-Active RDC's

on Basis of the Two Preceding Criteria

	Average Rank
ARAC	2
NC STRC	4
KASC	5
TAC	3.5
WESRAC	4
NERAC	2.5

Appendix I

Annual Fee-Paying Clients and Industrial Income of RDC's

RDC	1963	1964	1965	1966	1967	1968	1969	Industrial Income
ASTRA				41	5			$23,000 (1966-67)
ARAC	29	34	48	52	71	74	109	$937,980 (1963-69)
CAST			50 (approx)					$276,000 (1964-67)
NC STRC				34	31	31	39	$82,617 (1966-69)
KASC		17	47	57	55	40	56	$408,218 (1964-69)
TAC				23	22	27	28	$173,342 (1966-69)
WESRAC					27	40	48	$119,626 (1967-69)
NERAC					0	13	30	$170,727 (1967-69)
Totals	29	101	145	257	261	225	310	$2,191,510 (1963-69)

Annual Average of Fee-Paying Clients and of Industrial Income of Individual RDC's

	Clients	Industrial Income
ASTRA	23	$11,500
ARAC	60	$133,997
CAST	50	$69,000
NC STRC	34	$20,654
KASC	45	$68,036
TAC	25	$43,335
WESRAC	38	$39,875
NERAC	14	$56,909
Total Average	36	$55,413

Appendix J

Checklist of Abbreviations and Acronyms, with Page on Which Each Is First Cited

ACORDD	Action Council of Regional Dissemination Directors: 19
AEC	Atomic Energy Commission: 17
ARAC	Aerospace Research Applications Center (Bloomington, Indiana): 16
ASTRA	Applied Space Technology - Regional Advancement (RDC of Midwest Research Institute, Kansas City, Missouri): 12
BA	Biological Abstracts: 49
BATeam	Biomedical Applications Team: 19
CA	Chemical Abstracts: 49
CAST	Center for Application of Sciences and Technology (Detroit, Michigan): 18
CIP	Custom Interest Profile: 13
COSMIC	Computer Software Management Information Center (Athens, Georgia): 19
DOD	Department of Defense: 45
EI	Engineering Index: 49
ERIC	Educational Resources Information Center: 49
GE	General Electric: 4
IAA	International Aerospace Abstracts: 13
ITT	Institute of Textile Technology: 61
KASC	Knowledge Availability Systems Center (Pittsburgh, Pennsylvania): 18
MEDLARS	Medical Literature Analysis and Retrieval System: 49
NASA	National Aeronautics and Space Administration: 2
NC STRC	North Carolina Science and Technology Research Center (Research Triangle Park, North Carolina): 18
NERAC	New England Research Application Center (Storrs, Connecticut): 18
R&D	Research and Development: 3
RDC	Regional Dissemination Center: 17
RECON	Remote Console: 20
SAL	Subject Authority List: 13
SCAN	Selected Current Aerospace Notices: 17
SDI	Selective Dissemination of Information: 17
SIP	Standard Interest Profile: 39
STAR	Scientific and Technical Aerospace Reports: 13
STIF	Scientific and Technical Information Facility: 12
TAC	Technology Application Center (Albuquerque, New Mexico): 18
TATeam	Technology Application Team: 20
TPA	Technical Publication Announcements: 13
TSP	Technical Support Package: 18
TU	Technology Utilization: 69
TUSC	Technology Use Studies Center (Durant, Oklahoma): 18
WESRAC	Western Research Application Center (Los Angeles, California): 18

NASA-Langley, 1971 —— 34 CR-1763