REPORT

PROGRAM FOR TRANSFER RESEARCH AND IMPACT STUDIES

Semiannual Report: 1 January 1972-30 June 1972

Contract NASW-2362

DENVER RESEARCH INSTITUTE
UNIVERSITY OF DENVER

PROGRAM FOR TRANSFER RESEARCH AND IMPACT STUDIES

SEMIANNUAL REPORT

1 January 1972 - 30 June 1972

- Prepared for -

The Technology Utilization Office
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- Prepared by -

James P. Kottenstette
Jerome J. Rusnak
Eileen R. Staskin

Industrial Economics Division
Denver Research Institute
University of Denver

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REPORT HIGHLIGHTS

- The new Program for Transfer Research and Impact Studies [TRIS] continued and expanded upon the main research efforts of its predecessor, the Project for the Analysis of Technology Transfer [PATT].

- Continued efforts included:

  Questionnaire follow up of 3,564 TSP requesters;

  Interviews with 160 persons adapting NASA technology;

  Preparation and update of 30 technology transfer example files;

  Review of 567 NASA-related newspaper and magazine clippings; and

  Maintenance of a technology transfer library containing 2,600 titles.

- New efforts included:

  The Direct Benefits Analysis;

  Preparation of a model of the technology utilization processes;

  Distribution of a bimonthly newsletter; and

  An analysis of new mechanisms for distribution of NASA technical information.

- Separate studies of two technical areas--nondestructive testing and fracture mechanics--provided new insights about the ways technology, created originally for NASA purposes, is being utilized to solve nonaerospace problems. The studies also provided a useful contrast between the transfer and the diffusion processes in technology utilization.

INTRODUCTION

The Program for Transfer Research and Impact Studies [TRIS] was initiated at the University of Denver Research Institute early in 1972 under a contract with the National Aeronautics and Space Administration. The new program is designed to extend and expand upon most of the research activities conducted on the Project for the Analysis of Technology Transfer [PATT], which completed its fourth and final year in March 1972. TRIS will continue to develop technology transfer profiles, to maintain a data bank containing detailed information on nonaerospace applications of space program technology, to conduct special research tasks designed to analyze impacts of the transfer programs of NASA's Technology Utilization Office, and to operate a library which can serve as a resource for persons involved in the study of the technology transfer process.

The major difference between the two projects is that TRIS is conducting a full-scale analysis of NASA's impact on society through an examination of how mission objectives have contributed to beneficial changes occurring in such major areas of human concern as environment, safety, education, health, communications and transportation.

This report reviews the progress made in achieving TRIS research objectives during the first six months of 1972.

SECTION I. TRIS RESEARCH ACTIVITIES: JANUARY-JUNE 1972

Research activities conducted under the Program for Transfer Research and Impact Studies [TRIS] during the period of January 1 through June 30, 1972 are reviewed in this section.

Tech Brief-Technical Support Package Program

During the first six months of 1972, TRIS continued to code requests for Technical Support Packages [TSP's] that had been sent to NASA field centers by persons seeking additional information related to Tech Briefs. From January 1971 through January 1972, TSP requests had averaged approximately 2,200 per month. In February 1972, the number of requests processed by TRIS dropped by more than 50 percent and continued on a downward trend to a total of 409 TSP requests in June.

In attempting to understand this sharp decrease, TRIS initiated an analysis of the different factors that appeared to be influencing changes in the request behavior of TSP users. The results of that analysis are presented in Section II.

Transfer Documentation Activities

In order to obtain information concerning application activities associated with the use of NASA-generated technology, questionnaires are mailed to TSP requesters six months following the date of their request. This delay is considered sufficient time to allow TSP users to reach tentative conclusions concerning applications for the technologies. During the first half of 1972, TRIS distributed 3,564 questionnaires.

Those persons who indicated on the questionnaire that they made substantial progress in their attempts to adapt the aerospace technology were selected for additional contact. During this reporting period, TRIS personnel conducted approximately 160 telephone interviews with such persons. Appendices A and B of this report present, in summary form, results of this type of transfer documentation effort.

Technology Transfer Profiles

The preparation of transfer profiles, a major program effort initiated under the Project for the Analysis of Technology Transfer [PATT] in June 1970, continued to be an important part of TRIS activity in 1972. By June 30, six of these profiles had been published,

and four additional profiles were being prepared for publication in late 1972. Also, a special report which is profile-related, entitled A Case Study in Technology Utilization: Fracture Mechanics, was published in May 1972.

These profiles were concerned primarily with examining industrial applications of aerospace technology within particular fields of technology [e.g., cryogenics, nondestructive testing]. Under TRIS, profile development has been expanded to include documents that will assess the impact of aerospace technology in the solution of public sector problems [e.g., air pollution monitoring]. A more detailed discussion of profile development is presented in Section III; transfer example summaries prepared for use in the nondestructive testing and visual display systems profiles are presented in the appendices of this report.

Direct Benefits Analysis

Early in 1972, TRIS personnel undertook a full-scale analysis of different ways civilian aerospace activities have contributed directly to selected areas of social concern. The primary purpose of this analysis has been to facilitate thoughtful discussion of the Agency's role in various areas of national interest.

This special task was focused on identifying NASA contributions to six important areas of human concern: environment, safety, health, transportation, communications, and work and productivity. During this reporting period, major emphasis was placed on determining significant changes that have been occurring in each of these areas and on identifying what specific NASA programs, if any, have contributed directly to such changes.

Other TRIS Activities

Technology Utilization Compilations. During this reporting period, TRIS continued to examine transfer activity associated with the Compilations area of the Technology Utilization Office's Special Publications program. Compilations, which have been published as a series since 1967, aggregate and briefly describe innovations, concepts, manuals, and handbooks related to a particular technological subject area [e.g., Cryogenics, Assembly Technology, Management Techniques]. Two changes were made in the composition of Compilations in late 1970 that led to a significant increase in the volume of technical information being distributed by the NASA centers: the inclusion of a detachable reader service card, which enabled readers to request additional information on individual items described in the document; and the addition of selected items which had previously been published and distributed as Tech Briefs.

An initial analysis of reader service card data determined that thousands of Compilation recipients were indicating a broad interest in NASA technologies announced through the Compilation program. [For a more detailed discussion of this study, see Section IV of the PATT Final Report, July 1972.] In late spring 1972, plans were initiated to examine the second phase in Compilation effectiveness--that of determining how and to what extent the NASA innovations actually are being utilized once the information has been received. This program, which will involve mail questionnaires and subsequent telephone interviews, will begin in the latter part of 1972.

A Model for Technology Utilization. A paper, entitled "The Utilization of New Technology in the Public Interest," was prepared during the latter part of this reporting period for presentation at the September 1972 American Society of Mechanical Engineers' Aerospace Division Conference on "Aerospace and Society in the Seventies: The Challenge of Tomorrow." This paper articulated the essentially different but complementary processes of technological diffusion and technology transfer in the secondary application of mission-oriented R&D. It also provided a perspective on the Technology Utilization Office in its efforts to make aerospace technology accessible to persons and organizations that are not somehow aligned with the aerospace sector. The paper is currently being considered for publication in Research Management, a publication of the Industrial Research Council.

TRIS Newsletter. In response to the needs expressed by Technology Utilization Officers at the NASA field centers for verified, up-to-date information on discrete transfers of space program technology, the distribution of a bimonthly "TRIS Newsletter" was initiated in April 1972. The first two newsletters dealt primarily with transfer examples associated with Tech Brief-Technical Support Package program users. Future newsletters will also include transfer cases resulting from other Technology Utilization Programs, such as Regional Dissemination Centers, Technology Application Teams, and Special Publications, as well as license and waiver cases.

Technology Transfer Example Files. TRIS continued to maintain data files containing transfer cases associated with space program technologies, both to aid in the preparation of the technology transfer profiles discussed above and to provide interested persons with ready access to descriptions of NASA-related transfer activities. By the end of June, 423 files had been established, containing 867 individual PATT/TRIS cases and more than 50 cases from other sources [e.g., Regional Dissemination Centers, Biomedical Application Teams]; 20 of the files were created in 1972. During the past two years, 171 files have been updated one or more times [10 in 1972], including the preparation of comprehensive file summaries. These summaries describe the NASA technology and its role in meeting mission objectives; then, they present one or more examples of how different

organizations or individuals outside of NASA have utilized the technology.

NASA-Related News Clippings. Throughout this reporting period, TRIS personnel continued to review news items taken from selected magazines and newspapers distributed in the United States and Canada. The clippings, which expand the program's sources of leads to technology transfer activities, were compiled for NASA's Technology Utilization Office by a professional clipping service. By the end of June, TRIS had processed a total of 567 news items that referenced the civilian aerospace program's activities. Those items indicating evidence of transfer activity were selected for follow-up and, subsequently, were included in the transfer example files; in some cases they were used in transfer profile preparation.

Technology Transfer Library. The collection in the library, which was established under PATT in 1968, increased to more than 2,600 titles during the first half of 1972.

SECTION II. TECH BRIEF-TECHNICAL SUPPORT PACKAGE PROGRAM

The Program for Transfer Research and Impact Studies has continued to maintain a data bank to facilitate the collection of information on nonaerospace applications of technology developed initially for use in NASA programs. This effort was carried out through a process of systematically acquiring applications data provided by users of Technical Support Packages [TSP's] associated with NASA Tech Briefs. By the end of June 1972, a cumulative total of 81,900 cases had been processed into the data bank, of which more than 98 percent were initiated by TSP requests that had been sent to the NASA field centers.

During the first six months of 1972, TRIS received information concerning 5,977 requests for TSP's that had been sent to various NASA field centers. This number, as shown in Figure 2-1, represents a sharp decline from the 12,931 requests received during the same time period in 1971.

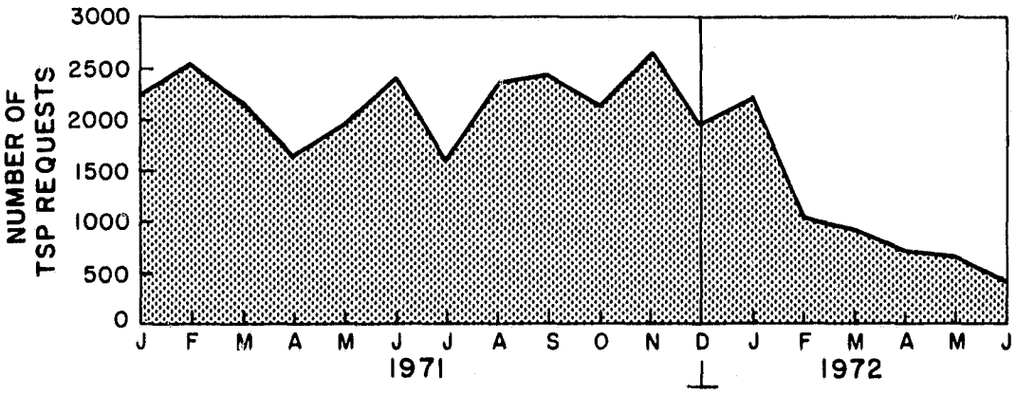

Figure 2-1. Monthly Requests for Technical Support Packages: January 1971-June 1972

In February 1972, the number of TSP requests dropped by more than 50 percent from a monthly average of approximately 2,200 requests in 1971, and the downward trend continued to a low of 409 requests in June. While the data seemed to indicate a decline in the number of TSP's requested as a result of Tech Brief distribution, it was found that the actual volume of TSP's being distributed by NASA

field centers essentially doubled compared to the previous year. In an attempt to understand the changes taking place in the program, TRIS initiated an analysis of the different factors that are influencing the ways in which the nonaerospace community acquires space program technology. This section discusses the relative importance of each factor identified and investigates the changing nature of the total dissemination program.

Tech Brief Production

One of the first factors considered as a possible explanation for the decline in TSP requests generated through the Tech Brief program was Tech Brief production. Were there more Tech Briefs published and distributed in the early part of 1971 and fewer during the latter months? Was Tech Brief production significantly different during the first six months of 1972?

In 1971, 511 individual Tech Briefs, organized into nine technical categories, were published and distributed [approximately 13,000 persons receive Tech Briefs in one or more categories]. Another 147 Tech Briefs were made available during the first half of 1972. Figure 2-2 shows the number of new Tech Briefs distributed, by month, during this 18-month period.

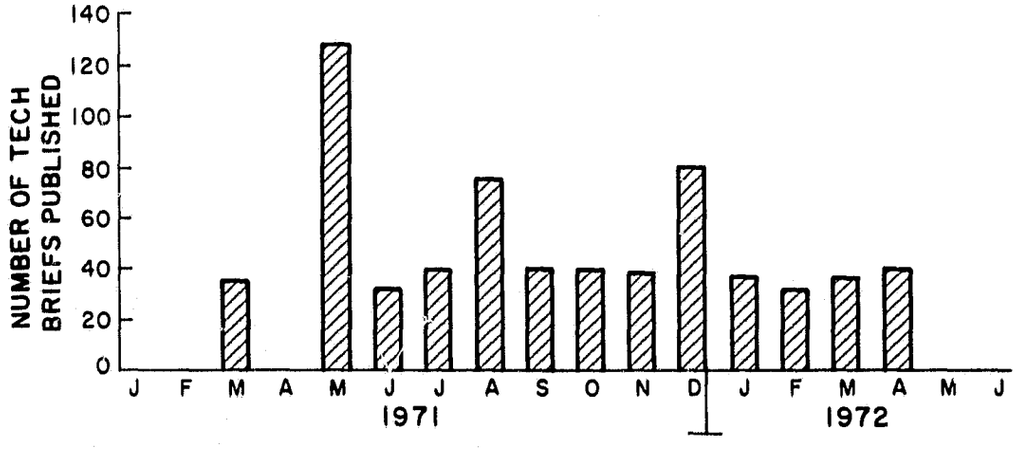

Figure 2-2. Tech Brief Distribution, by Month, from January 1971-June 1972.

As the data indicate, no important differences occurred in the number of Tech Briefs produced in this 18-month period. Of the 658 Tech Briefs produced during that period, 35 percent were distributed between December 1971 and April 1972. Considering a normal time lag--that is, from time of receipt of a Tech Brief to the point a TSP is requested from a NASA center--the first six months of 1972 should have witnessed a much higher volume of TSP requests than was illustrated earlier in Figure 2-1. It was concluded, then, that the decline in TSP requests processed by TRIS did not result from any significant changes in the rate of Tech Brief production; rather, changes in the distribution mechanisms for Tech Brief information are responsible for this decline.

Three New Communication Mechanisms

During the past 30 months, three new mechanisms for disseminating information on innovations available from NASA have evolved: improved Technology Utilization Compilations, Small Business Administration [SBA] announcements, and SBA's announcement of new Tech Briefs in the Commerce Business Daily.

Technology Utilization Compilations. Late in 1970, the Technology Utilization Office made two basic changes in the composition of Compilations that had a significant impact on reader interest in available NASA technologies: the inclusion of a detachable reader service card, which enabled interested readers to request additional information on individual items described in the document; and the addition of selected items which had previously been announced in individually distributed Tech Briefs.

The first of these improved Compilations appeared in January 1971; by the end of the year, 32 had been distributed. In 1972, 14 Compilations had been distributed by the end of June, bringing the total to 46 new Compilations. During this 18-month period, a total of 14,986 Compilation reader service cards were returned to NASA, generating requests for 53,372 individual support packages; more than 28,000 of those requests were received in 1972.

The unanticipated volume of Compilation reader service cards, and the multiple requests associated with most cards, led to the introduction of a computerized system for the management of TSP requests and field center response. This system went into effect in April 1972, and now provides a method for recontacting persons

receiving TSP information for the purpose of application analysis. A formal effort to follow up on Compilation-initiated applications is being formulated.

Small Business Administration Announcements. In December 1971, the Small Business Administration [SBA] distributed a document, entitled Testing Methods and Techniques: Quality Control and Nondestructive Testing [designated NASA/SBA No. 1], that was identical in size and format to the TU Compilations. This publication, which reported only NASA program technology, offered further documentation on 25 items, 13 of which had previously been announced through the Tech Brief program. In January 1972, 514 reader service cards had been returned; and by the end of June, 994 cards had been returned, generating 3,005 requests for individual support packages. More than one-half of those packages requested were for Tech Brief items.

SBA then changed its announcement format to that of a flyer containing 15 abstracts of current NASA Tech Briefs related to a particular subject matter and a detachable reader service card to facilitate the reader's task in acquiring TSP's. Three such flyers were distributed during the first three months of 1972: NASA/SBA F-1, "Electrical/Electronics Technology"; NASA/SBA F-2, "Instrumentation Technology"; and NASA/SBA F-3, "Metalworking Technology." By the end of June, 4,113 reader service cards had been returned, with requests for 13,828 individual TSP's.

Thus, during the first six months of 1972, 16,833 requests for TSP's were generated by the four SBA publications alone. Distribution of these support packages is also accomplished through the NASA field centers, and it is presently managed through the computerized system that makes a transfer follow-up effort feasible.

Commerce Business Daily Announcements. On December 15, 1969, SBA began publishing abstracts of current NASA and AEC/NASA Tech Briefs in Commerce Business Daily [CBD], a U. S. Department of Commerce Publication. A "cut-out" reader service form was included, thereby enabling interested readers to request the TSP's associated with the Tech Briefs described in the publication.

The first announcement, which described five Tech Briefs, generated requests for 436 individual TSP's. By the end of 1970, a total of 11 announcements had been placed in CBD, describing 76

Tech Briefs, and generating 6,895 TSP requests. Initial response to these announcements was so favorable, SBA continued this activity in 1971 with two announcements per month in CBD. Another 196 Tech Brief abstracts were presented in 23 announcements, generating 15,749 requests for TSP's. During this two-year period, then, a total of 272 Tech Brief abstracts were published in 34 editions of CBD, resulting in 22,644 TSP requests.

In 1972, SBA made five more announcements in CBD, describing 41 new Tech Briefs, which generated approximately 5,000 TSP requests. Since the response rate was so high for these new Tech Briefs, and since many of the TSP's had not yet been completed in support of those announcements, the SBA and NASA decided to discontinue this activity temporarily in March 1972. No further announcements had appeared in Commerce Business Daily by the end of this reporting period.

During the two years prior to 1972, all TSP requests generated by CBD announcements were processed at NASA field centers and combined with TSP requests generated through normal Tech Brief distribution. The TSP request information was then forwarded to DRI for inclusion in the data bank and subsequent follow-up. It is important to note that the CBD announcements were responsible for more than one-half of the data bank entries in the two-year interval: approximately 42,000 total, with 21,500 via the SBA.

In January 1972, another important change reduced the number of TSP requests as seen by TRIS through the transfer data bank. The requests generated by CBD were combined with the other SBA and TU Compilation reader service cards for processing and distribution by NASA. One immediate result was the reduction in TRIS data bank entries of approximately 6,000 TSP requests for the first half of 1972.

Implications

The significant changes in the extent of TSP distribution resulting from the introduction of three new dissemination mechanisms, as well as the present limitations for TRIS application analysis, are clearly demonstrated in Figure 2-3. In each of the three time periods illustrated in the Figure, the shaded areas represent the proportion of TSP requests involved in DRI transfer follow-up activities. Whereas in 1970 all TSP requests were entered into the data bank, by June 1972 only 10 percent of all known TSP recipients were involved in the follow-up program.

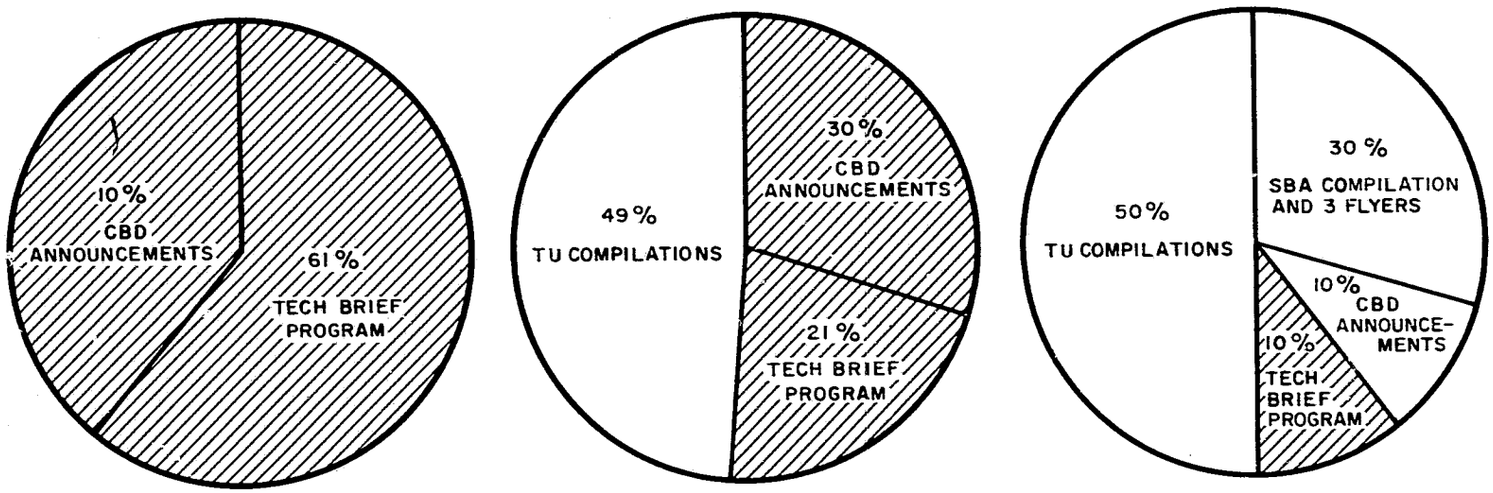

Figure 2-3. Change in TSP Request Pattern, by Year, Resulting from the Introduction of New Dissemination Mechanisms, and the Proportion of Total TSP Requests Involved in Application Analysis.

While the number of TSP requests generated through these new mechanisms has broadly expanded program participation by the nonaerospace community [requests in 1972 already surpass all of 1971], their transfer effectiveness has not yet been determined. Assuming that their transfer effectiveness is being maintained at former program levels, then, at least three new options are open to the Technology Utilization Office:

- Since the TU Compilations, SBA flyers, and CBD announcements reprint only a part of the original Tech Brief, then the backlog in announcement of reportable items might be reduced by omitting the usual step of formal Tech Brief preparation. *

- The reader service card approach could be evaluated for its suitability in the normal Tech Brief distribution through the NASA mailing list.

- Flyers or similar abbreviated announcements might be used to provide new user access to previous TU announcements of new technology.

The importance of the third option should not be underestimated. The CBD and SBA mechanisms reach a different audience than the one reached through the normal NASA mailing. In terms of program effectiveness, it must be remembered that technology announcements even eight years old represent new technology for most organizations confronted with technical problem-solving situations. The concept of retrospective access through a flyer or brochure represents a strategy that could add a whole new dimension to NASA's efforts to involve the nonaerospace community in the technological gains of mission-oriented R&D.

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* While a portion of the reportable items are not suitable as Tech Brief material by definition, substantial editorial work is required for Compilation preparation as opposed to the SBA flyers and CBD announcements.

SECTION III. TECHNOLOGY TRANSFER PROFILES

The primary output of TRIS during the six-month reporting period continued to be the technology transfer profiles. To date, a total of seven profiles have been prepared for specific fields of technology--plastics, lubrication, contamination control, fire safety, cryogenics, nondestructive testing and fracture mechanics. In each of these fields, the presentations described overall trends in the technology; related significant NASA contributions by citing appropriate technical and economic impact data; examined major ways such contributions have been disseminated to persons outside of the aerospace community; and, finally, reviewed a number of transfer case histories illustrating how the disseminated technologies are being used in nonaerospace sectors of the American economy.

The two profiles prepared during this report period--nondestructive testing and fracture mechanics--uniquely contrast the major ways technology, created originally for aerospace purposes, is utilized by people not necessarily aligned with NASA's objectives. This section briefly highlights these presentations and then focuses on the insights about technology transfer and technology diffusion that were gained in preparing these reports.

Nondestructive Testing

NASA's extraordinary reliability and quality control requirements needed to assure mission success led the Agency to maintain a crucial interest in the techniques and equipment for nondestructive testing [NDT]. The coincidental nonaerospace demand for safer and more reliable products not only caused a rapid growth in the NDT field, but in many cases also encouraged manufacturers to look to NASA for advanced NDT technology. It was not surprising, then, to learn that the transfer of NASA-generated NDT technology has been far-reaching.

In the course of meeting its own requirements, NASA has affected virtually every dimension of the nondestructive testing field, from the design and application of test equipment to the training of new NDT specialists. Since the discovery of new NDT techniques is an infrequent occurrence, the vast majority of NASA's contributions have tended to incrementally advance the total knowledge base in the field by building on previous innovations. It is in this building block

fashion that the Agency's contributions to NDT can be best understood.

In examining how NASA attempted to link aerospace technology generators with potential users in the private sector, this profile considered dissemination via formal publications, special conferences and technical societies. In addition, this profile illustrated, in a new way, the importance of time in the technology transfer process: technology transfer rarely occurs quickly. As expected, the longer a potential adopter has had the NASA technology the more likely he is to have progressed to an advanced stage in its application. Technology Transfer Example Summaries describing the ways in which different organizations and individuals have utilized NASA-generated nondestructive testing technology are presented in Appendix A.

Fracture Mechanics

It would be difficult to find a subject more important to the safe design of critical engineering structures, such as aircraft, spacecraft, bridges, and nuclear reactors, than fracture mechanics and the associated discipline of fatigue. Nevertheless, engineers have been hampered by the lack of adequate analytical tools to deal effectively with the problems associated with designing such structures. The emergence and rapid acceptance of fracture mechanics during the past decade, however, has provided a new benchmark for best practice in the design and construction of critical structures. This highly technological discipline has the power to virtually eliminate the hazard of catastrophic structural failure.

The fracture mechanics profile afforded a study of one of the most significant technological achievements flowing out of NASA's research efforts. Engineers at the Lewis Research Center developed the so-called "plane strain fracture toughness test" and, for the first time, could relate the size of ever-present flaws in a material to the load carrying capability of that material. Whereas the innovations considered in the NDT profile reflected numerous incremental advances to the existing body of knowledge in the field, the development of the fracture toughness test redefined best practice in the structural design field.

A second major focus in this study was on the little-known role of NASA within specialized technical communities. Because of its specific mission requirements, many of the Agency's contribu-

tions to technology find other uses only after some modifications have taken place. In fact, the six previous reports in this series all were focused on such transfers of NASA-generated technology. This study, by contrast, identified NASA technology adopted by nonaerospace engineers with little or no adaptation. NASA scientists and engineers are often part of a technical community whose members share a common concern for special technical problems. In such instances, innovations introduced by NASA to achieve its mission objectives can be readily applied to nonaerospace problems and thereby rapidly diffuse through a community to become incorporated in common practice.

Technology Utilization--Through Diffusion and Transfer

The main objective of NASA's Technology Utilization Program has been to provide for secondary application of NASA-generated technology. This objective was, of course, the intent in the legislative mandate to "provide for the widest practicable and appropriate dissemination" of the results of NASA research and development efforts. There are many specific ways that NASA has responded to that mandate, and they can be conveniently categorized into one of two mechanisms: diffusion and transfer.

The diffusion mechanism is characterized, in one way, by the movement of technology within a community of interest, aligned by professional societies such as the American Society of Mechanical Engineers, the American Society for Testing and Materials, and the Society of Automotive Engineers. To assure the broadest use of their fracture testing research, NASA engineers have chosen to communicate with the nonaerospace community primarily through the publications and activities of the American Society for Testing and Materials--particularly the E-24 Committee on Fracture Testing of Metals. Figure 3-1 illustrates this linking mechanism between two socioeconomic sectors having different purposes and functions, but areas of similar technical needs. The most noticeable characteristic of this mode of diffusion is that it bridges contemporary sectoral alignments. Engineers and scientists in professional communities associate with one another because of particular technical interests and problems, in addition to serving in organizations that make up the generally defined socioeconomic sectors [e.g., aerospace or the energy industries]. Often these professional communities, by virtue of their technical alignment, introduce the new innovations, or "best practice," of one sector into another sector.

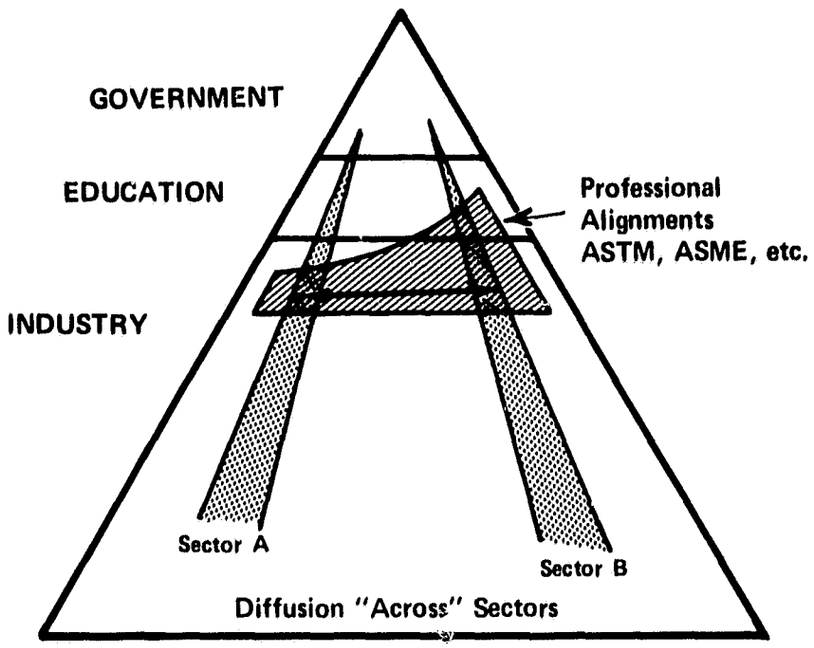

Figure 3-1. A Section Through the Societal Pyramid Showing the Linking Action of Professional Alignments that Facilitate Intersectoral Diffusion.

Technology diffusion can be contrasted with technology transfer, a mechanism which is characterized by discrete transactions. The preparation and dissemination of documentation, the movement of people, and actions of technology brokers all serve to link the originating sector with individuals and organizations outside that sector in a discrete rather than continuous fashion. Figure 3-2 illustrates the transaction concept and the characteristic independence of the adopting organizations in terms of professional or sectoral alignment. The bulk of these transactions or transfers are facilitated by the originating sector exclusively and become systematic only through policy implementation, which results in identification, documentation, and information dissemination for new technology. Such implementation was broadly evidenced in the nondestructive testing profile.

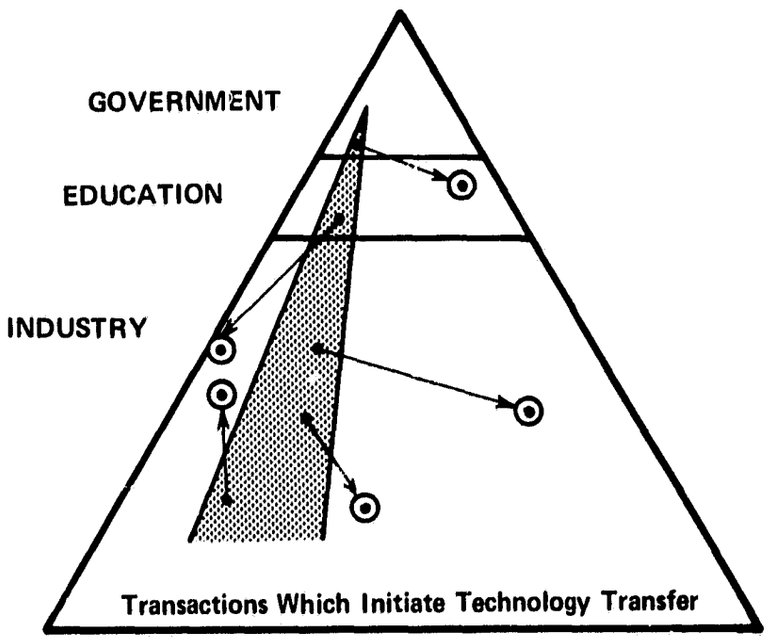

Figure 3-2. A Section Through the Societal Pyramid Showing the Technology Transfer of Transactions Which Introduce New Technology in Organizations Not Aligned with the Generating Sector.

Finally, the summaries of transfer cases prepared for a profile on visual display systems [to be published during the second half of 1972] were completed during this reporting period and are included in Appendix B. Two of these summaries serve to further illustrate the diffusion and transfer mechanisms. The Automatic Picture Transmission [APT] system characterizes the diffusion mode. [See "Weather Satellite Image Display" Transfer Example Summary in Appendix B.] This unique television system has been providing satellite cloud cover pictures via inexpensive ground stations around the world for over six years. Different communities, both national and international, aligned by the common problem of providing rapid and accurate weather forecasts, have adopted this innovation because it represents a stepwise improvement in predictive capability with little or no adaptation required.

A case involving the Perkin-Elmer Corporation in Pomona, California provides an illustration of a common transfer mechanism.

[See "Infrared Scanner for Nondestructive Testing" Transfer Example Summary in Appendix B.] Perkin-Elmer learned about an infrared technique for detecting the breakdown of power transistors from a NASA Tech Brief. After evaluation, the procedure was employed in the testing of components used in several of the company's products. In this case, the Tech Brief and its associated Technical Support Package provided the basis, or mechanism, for a transfer transaction between generator and adopter.

APPENDIX A

Summaries of Technology Transfer Reports Involving
NASA-Generated Nondestructive Testing Technology

SUMMARIES OF TECHNOLOGY TRANSFER REPORTS INVOLVING NASA-GENERATED NONDESTRUCTIVE TESTING TECHNOLOGY

NASA CONTRIBUTIONS	TRANSFER STAGES: Awareness Cont.*	Awareness Term.	Evaluation Cont.	Evaluation Term.	Prototype Cont.	Prototype Term.	Diffusion Cont.	Diffusion Term.
ULTRASONICS								
• Mechanized Ultrasonic Scanning System			21897** 54934					
• Ultrasonic Delta Technique Ultrasonic Hand Tool					15139		59201	
• Ultrasonic Measurement of Residual Stress					31840			
RADIOGRAPHY								
• Radiographic Film Reference					49702			
• Solid State Imaging Device				21588	20501 58901			
CHEMICAL AND SPECTROGRAPHIC ANALYSIS								
• NDT Spot Test For Metal Identification					44538 44636 44768 45010 47012 47074 47744 48880 66874			
OTHER NONDESTRUCTIVE TESTING TECHNIQUES								
• NDT Measurement of Residual Stress			27106 54932	26855	26854			
• 1966 Nondestructive Testing Symposium					56301 56302 57802 57803			
• Fiber Optics Detect Surface Irregularities							30502	
• Optical Strain Measuring Device			53850					
• Sonic Impedance NDT				48782				
• Infrared Scanner for Nondestructive Testing					57574		70001	
GENERAL HANDBOOKS								
• Nondestructive Testing Manuals					5170 6706 27624 27634 27642 27744 31534 40622 53789		53871	
• Nondestructive Testing of Brazed Components	24833		24342 27305					
• Nondestructive Testing of Honeycomb Structures					4303			
• Strain Gage Installation Manual					51572 51950 52304			

* The action status, continuing or terminated, of transfer cases at the time DRI-TRIS contacted users. Cases are classed as terminated when (a) no further adaptation or adoption is contemplated, (b) a better technical alternative has been found, or (c) continued transfer activity is not economically feasible.

** Numbers in columns refer to TRIS case numbers.

MECHANIZED ULTRASONIC SCANNING SYSTEM

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Nondestructive testing in the inspection of welds usually involves X-ray or ultrasonic methods. In space vehicles, the range of material thicknesses encountered limits the usefulness of radiography for detecting lack-of-fusion and lack-of-penetration flaws. Using ultrasonics to inspect the flaw content of welds in booster stages and propellant tanks has been inhibited by the necessity of submerging the test weld in water or providing a water flush over the inspection surface.

Raymond Evans and J. A. MacDonald of Marshall Space Flight Center designed and developed a mechanized ultrasonic scanning system, publicized in Tech Brief 68-10004. Their instrument is built around a water column probe that eliminates the need for submerging or flushing the test specimen. The probe is a transmitter and receiver consisting of an ultrasonic transducer enclosed in a water filled cylinder. The lower end of the cylinder is covered with a rubber diaphragm that seals the unit and permits transmission of the ultrasonic beam to the weld. The system consists of the probe, an ultrasonic flaw detection unit, a recording unit, and special tooling to move the probe along the inspection surface at a rate in excess of one inch per second.

The F. Yeager Bridge and Culvert Company in Port Huron, Michigan (54934) plans to use the system as soon as better techniques are developed for interpreting test results. The company fabricates steel bridges for the Michigan Highway Department. The Department currently requires X-ray testing of bridge welds because the results may be interpreted objectively. The portability and recording features of the ultrasonic scanner are attractive to Yeager Bridge; considerable savings are anticipated from its use.

Engineers at De Laval Turbine, Incorporated in Trenton, New Jersey (21897) have evaluated the system and found it to be satisfactory for the company's needs if a suitable method or in-house

expertise can be developed to interpret the ultrasonic test results. A company spokesman reported that the NASA system is potentially a more efficient way to conduct quality control testing of De Laval's products such as compressor wheels.

Control Numbers

Tech Brief Number: 68-10004
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 21897, 54934
TEF Number: 380
Date of Latest Information Used: July 8, 1971

ULTRASONIC DELTA TECHNIQUE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Marshall Space Flight Center (MSFC) sought a nondestructive testing technique to rapidly inspect butt welds in aluminum alloys and detect the lack of weld penetration not readily seen in the radiographs. With the increasing demands for high vehicle reliability, low cost, sensitive techniques, and automated testing, only a nondestructive test system having exceptional capabilities could achieve the level of defect detection required by MSFC. Since welding is an essential part of fabrication of space vehicles, accurate nondestructive evaluation of weldments requires use of the most advanced methods that are available. The Delta technique, an ultrasonic weld inspection technique developed by the Research Division of Automation Industries, Incorporated in Boulder, Colorado (59201), offered much promise for accomplishing the weld inspection requirements of MSFC. This technique was developed to detect randomly oriented weld defects. In the laboratory, the Delta technique had been used successfully for detecting these defects. The company was awarded a NASA contract (NAS 8-18009) in 1967 to transform the Delta technique from a laboratory tool into a reliable inspection method for production weld evaluation.

The Delta technique uses two or more transmitting transducers which introduce ultrasonic sound energy into the material being investigated at an angle that produces shear-wave energy in the material; for welds it is introduced into the adjacent parent material. The sound propagates in the material until it strikes an interface, which is anything differing in acoustic impedance from the parent material and interrupting the propagation pattern of the sound beam. The interface may be an inclusion, crack, or absence of weld penetration or fusion. At the interface the sound energy may be (1) simply reflected; (2) converted in mode from shear to longitudinal; or (3) reradiated. Experiments have shown the occurrence of this latter phenomenon; in concept the defect acts as a new source of the sound energy. Any energy redirected from the defect can provide information about the defect. The energy received at the receiving search unit (RSU) conveys information to either an oscilloscope or a printout about the defect, regardless of which path it followed to get there. The RSU is usually focused for increase in the angle of capture of the redirected energy. In thinner materials the lengths of the various paths are so short that they give the

appearance of almost simultaneous occurrence; in thicker materials the various paths and modes can be separated and identified. The nature and operation of two Delta configurations, the Delta Wheel and the Delta Manipulator, are described in the TSP for Tech Brief 70-10514.

The contracted development at Automation Industries produced an operational Delta technique and equipment which detected the weld flaws of primary concern in aluminum alloys at inspection rates of 50 feet per hour and did so with greater accuracy than radiography. Destructive analysis of 18 feet of weldment tested showed that about 80 percent of total defects were detected by the Delta technique, whereas only 36 percent were caught by radiography.

Since the NASA contract was completed, Automation has been producing similar equipment for similar applications. Approximately 25 companies have purchased the Delta Manipulators for $790.00 each. A single company may have as many as 100 of these units since they are the key to using the Delta technique. NDT experts report that the Delta technique was immediately used to replace standard ultrasonic methods in many applications as soon as the first descriptions of its operational capabilities were published (Automation's report in 1968, NASA CR-61952). Many users fabricated their own version of the Manipulator for in-house use with standard transducers.

Control Numbers

Tech Brief Number: 70-10514
NASA Center: Marshall Space Flight Center
PATT Case Number: 59201
TEF Number: 387
Date of Latest Information Used: August 9, 1971

ULTRASONIC HAND TOOL

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The Boeing Company, under contract to Marshall Space Flight Center, has invented a portable, electrically-powered ultrasonic hand tool for rapid scanning of spot weld discontinuities in small, inaccessible places. The unit consists of an ultrasonic search unit attached to a solenoid in a housing assembly which includes the scanning motor. The solenoid is fitted with a recording stylus in contact with pressure sensitive paper to provide a read-out of the results. In operation, the front end of the scanner is placed on the area being examined. The spiral scanning motion of the ultrasonic search unit is recorded as a spiral pattern on the pressure sensitive paper. Weld discontinuities will appear as breaks in the spiral pattern.

Moragne Machine and Manufacturing Corporation in Freeport, Texas (15139) is using several copies of the hand tool, which were fabricated in-house, to inspect welds on equipment produced by the company for industrial use. Dr. Moragne, company president, has used this and other NASA TSP's as the basis for an extensive investigation of ultrasonics. His investigation has produced several inventions: a patented ultrasonic precipitator to clean air in the Houston Astrodome; a carbon black plant and a fire brick plant; and a welding method in which the work piece is vibrated ultrasonically to produce a superior weld. Dr. Moragne attributes approximately $3.5 million of increased sales to his use of the NASA technology. This is, in part, indirect since he includes all benefits which have evolved from his reading the TSP.

Control Numbers

Tech Brief Number: 66-10289
NASA Center: Marshall Space Flight Center
PATT Case Number: 15139
TEF Number: 386
Date of Latest Information Used: July 12, 1971

ULTRASONIC MEASUREMENT OF RESIDUAL STRESS

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Metal machining and assembly processes can produce residual stress which can cause fatigue failure. Residual stress levels inside a metal are difficult to analyze, although surface residual stress can be analyzed by X-rays, and dynamic surface stresses are observable with strain gage and photostress techniques.

In 1967, R. W. Benson & Associates, Incorporated, under contract to Marshall Space Flight Center, developed an ultrasonic method for stress analysis in which the patterns of wave propagation inside the metal provide a basis for analysis. The method involves mounting two Y-cut crystals with their axes of vibration at right angles. The crystals generate and receive signals, and the degree of stress in the metal is revealed by timing the phase shift between the two signals. Stresses within the metal can be measured with this method by varying the signal frequency. The penetration depth of a surface wave is approximately one wavelength, so that deeper penetration can be achieved by using lower frequencies. This method was described by NASA in Tech Brief 67-10428.

Lodding Engineering, a division of Thermo-Electron Corporation in Auburn, Massachusetts (31840), is proceeding with development of a new product based on the Tech Brief. The firm's engineers had been experimenting with methods of nondestructively measuring residual stresses when they learned of the new technique. Visits to Marshall convinced them that the principles embodied in the NASA technology could be applied to a new product. Subsequent development work yielded two portable prototype instruments which work well on aluminum alloys but provide only qualitative data on ferrous alloys. The instruments give essentially instantaneous results under field conditions as opposed to at least an hour of preparation time for the strain gage techniques. Although redesign efforts are underway to improve the instrument's capability on ferrous alloys, the current model will be marketed by June 1972 in the price range of $5,000 to $10,000.

Market prospects are quite good, and development costs will probably be recovered during the first year. The product is expected to replace the use of strain gages in many applications.

Control Numbers

Tech Brief Number: 67-10428
NASA Center: Marshall Space Flight Center
PATT Case Number: 31840
TEF Number: 316
Date of Latest Information Used: March 23, 1972

RADIOGRAPHIC FILM REFERENCE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

When radiography is used for nondestructive testing, the resulting image must be interpreted to discover flaws in the test object. An improved "Reference for Radiographic Interpreters" (RRI) was compiled at North American Rockwell Corporation under contract to Marshall Space Flight Center. It provides a wider variety of X-ray film examples for each weld defect than are available in other X-ray film references. The RRI also contains examples of film quality, stainless steel welded tubing and acceptable weld conditions. The film slides are one inch by two inches and are contained in loose-leaf, celluloid folders for easy viewing. The slides are identified by a number, which can then be referenced to the summary sheet in the RRI for a detailed description of the particular discrepancy shown on the film strip. An interpreter who desired to familiarize himself with weld radiographs would view a numbered X-ray slide and make an evaluation of the observed defects. This evaluation would then be compared with the standard given in the summary sheet for that particular slide. The RRI was announced by NASA in Tech Brief 70-10189.

Quality control engineers at American Standards, Incorporated in Franklin Park, Illinois (49702) frequently use the RRI to evaluate X-rays of temperature sensors which are produced by the company. Prior to receiving the NASA reference, this quality control evaluation was based on less thorough references and required more time to complete. The sensors are used by customers in boilers, reactors, and laboratory equipment where safety requires a very stringent quality control.

Control Numbers

Tech Brief Number: 70-10189
NASA Center: Marshall Space Flight Center
PATT Case Number: 49702
TEF Number: 382
Date of Latest Information Used: July 12, 1971

SOLID STATE IMAGING DEVICE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The Electron Tube Division of Westinghouse Electric Corporation was conducting research for the development of light amplification panels when it was awarded a contract (NAS 8-21206) from Marshall Space Flight Center in July 1967. The contract redirected this research toward radiographic amplification panels and supported the development of working prototypes from the basic principles involved. One of these panels, together with a portable power pack and radio isotope source, can provide a briefcase-sized X-ray unit. The image may be preserved by photographing the panel display.

The new panel consists of a relatively simple, thin layered construction. It provides images of higher contrast sensitivity and better resolution over longer storage periods than are attainable with previous image amplifiers of this general type. The device also combines very high radiation sensitivity (10 milliroentgens, or less, of penetrating radiation required for optimum display, compared to 350 milliroentgens for a "Thorne" image amplifier) with fast image buildup and erasure capabilities. When excited by X-ray or gamma ray radiation directed through a test specimen, the image amplifier produces a daylight-visual image of the radiographic structural details in its field of view. These characteristics are achieved by the addition of two layers to a basic image amplifier and cascading this assembly with a modified "Thorne" panel. The two new layers are connected electrically in series. Radiation applied to the photoconductive layer reduces its resistance, which decreases the voltage drop across it; this increases the voltage across the electroluminescent layer causing a light pattern of the input energy to be produced. A Tech Brief was issued in 1968, which described the current state of the panel's development. The basic configuration has not changed since then, although considerable refinement has taken place.

The Westinghouse division, which is located in Elmira, New York (58901), has developed a potential new product as a result of the NASA contract. The company has sold approximately 20 laboratory built panels, worth a total of $20,000, for evaluation in medical, welding and other NDT applications. The invention appears to provide a significant advance in radiography, and the company is conducting a promotional campaign for commercial applications. If the panels are mass produced, the quality will be improved, and the cost will be reduced by a factor as great as 100.

Marshall has awarded two no-cost contracts for the development and evaluation of medical applications for a portable X-ray unit which uses the panel. Tulane University Medical School in New Orleans, Louisiana and Southeastern State College in Durant, Oklahoma have each received one of the $400 units. The Tulane project, initiated by NASA's Biomedical Application Team (BATeam) at the Research Triangle Institute in Research Triangle Park, North Carolina, will utilize the panel to monitor cancer growth. The natural growth rate will be minimally affected by the low radiation requirements of the panel. The Southeastern State College project, initiated by NASA's Technology Use Studies Center, will develop the unit's applications for veterinarians. The quick response and portability of the unit will be used to X-ray large animals in the field.

A major photographic company (20501) has used the TSP to invent a new electroluminescent device with potential medical and industrial applications. The NASA information was described as "quite valuable" in developing the unusual device. Prototypes have been successfully tested, and a patent is pending. It will be marketed after the patent is issued.

Atomics International, a division of North American Rockwell Corporation in Canoga Park, California (21588), evaluated prototypes of the panel for use in its quality control testing of one product: nuclear reactor fuel elements. Although the panel was satisfactory for this application and would have reduced costs, the company no longer makes this product.

Control Numbers

Tech Brief Number: 68-10363
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 20501, 21588, 58901
TEF Number: 117
Date of Latest Information Used: October 22, 1971

NDT SPOT TEST FOR METAL IDENTIFICATION

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

M. L. Wilson of Langley Research Center has compiled a flowchart indicating an ordered test sequence to permit rapid identification of metals and alloys. Even complex alloys can be identified within 30 minutes by personnel with very little training. The test requires only the application of standard chemical reagents to metal surfaces, spot-plate depressions or on filter paper. Colors or specific reactions produced by the reagents allow identification to be made. Only a minute amount of metal is destroyed, so the test is reasonably called nondestructive. All commonly used metals are covered by the procedures, which specify required amounts of reagents, reaction time and possible results. The flowchart also lists separate procedures for confirming the presence of individual elements in an alloy and an enumeration of nominal compositions of one hundred common alloys. In 1970, NASA announced the availability of the spot test TSP in Tech Brief 70-10520.

This TSP has been requested by more than 1,063 individuals throughout the country. Many requesters have found immediate applications for the procedure to the verification of alloys during manufacturing and scrap metal separation. One example of the interest shown in the technology is the Institute of Scrap Iron and Steel, Incorporated, which has distributed 350 copies of the Tech Brief to its member companies. The following examples are typical of the applications which have been made of the spot test.

Goodyear Atomic Corporation in Piketon, Ohio (44768) saved up to $15,000 between August 1971 and March 1972 by using the spot test on aluminum alloy compressor blades. Goodyear metallurgists anticipate similar savings of time and money in the future.

The Portland, Maine division of E. W. Bliss Company (44636) is using the spot test to identify metal alloys from which it produces parts for jet engines and fire fighting equipment. The primary application is in verifying stock material which may become mixed in the stockroom. The company has developed its own set of known comparison samples and estimates that the spot test procedure has eliminated the need to purchase more than $9,500 worth of spectrographic equipment and reference samples.

Chicago Vitreous Corporation (47012) uses the spot test to solve customer problems. The company sells porcelain enamel frit which is applied to products by the customer. About 75 percent of customers' application problems involve incorrect identification of substrate metals. The firm has saved up to $1,000 in commercial laboratory fees on several occasions.

The Houston Branch of Rockwell Manufacturing Company (48880), a producer of offshore oil rig equipment, uses the spot test as a standard procedure in processing customer complaints on malfunctioning equipment. Malfunctions often result from having used incorrect alloys in a given component, and the spot test quickly and conveniently provides a check.

Sanford Ink Company in Bellwood, Illinois (45010) is investigating the potential market for a new product based on the TSP. The proposed product would consist of a set of Sanford's magic marker type pens containing the reagents for conducting the spot test. This set would be sold with a copy of the flowchart from the TSP.

An industrial hygiene chemist with the New York State Department of Labor in Tonawanda (44538) is using the spot test to help identify health hazards associated with metal fabrication. He is particularly interested in alloy components such as beryllium and cadmium. The test provides quick results with sufficient accuracy for his work; he will continue to use it frequently.

The chairman of mechanical and engineering technology at The Pennsylvania State University in Middletown (66874) presently uses part of the spot test sequence in his course on materials and processes, and is planning to include the technology in his automotive design course. His primary interest in the method is testing for lead in brass alloys.

Material engineers with New Hampshire Ball Bearings, Incorporated in Petersborough, New Hampshire (47074) are using the spot test to verify alloy identification for incoming rough stock during fabrication and for finished bearings when there is a reason to suspect that the alloy is mislabeled. The spot test has replaced, in part, the in-house use of spectrographic analysis and saves at least two hours of time over this more expensive method each month.

The Research and Development Division of Kraftco Corporation in Glenview, Illinois (47744) has decreased the time required to analyze food processing problems which arise from the reaction of a food and atmosphere combination with the stainless steel equipment. By using the spot test, the steel alloy is quickly identified so that the reaction may be analyzed and prevented. The spot test has led to the selection of an alternative stainless alloy for a given application and to the diagnosis of incorrect alloys provided by a supplier.

Control Numbers

Tech Brief Number: 70-10520
NASA Center: Langley Research Center
PATT Case Numbers: 44538, 44636, 44768, 45010, 47012, 47074, 47744, 48880, 66874
TEF Number: 378
Date of Latest Information Used: March 17, 1972

NDT MEASUREMENT OF RESIDUAL STRESS
TECHNOLOGY TRANSFER EXAMPLE SUMMARY

C. D. Schwebel of the Boeing Company, under contract to Kennedy Space Center, originated a conceptual model for indirect and nondestructive measurement of residual stresses in metals. His suggestion is based on the fact that the electrochemical solution potential of a metal depends on the metal's condition of stress. The necessary apparatus for this residual stress measurement technique consists of two electrolytic cells, a differential galvanometer, and a reference specimen holder. One cell is placed on the metal surface to be tested and the other on the reference specimen. The operator loads the reference specimen until the galvanometer indicates the same potential from both electrolytic cells. At this point he measures the deflection in the reference specimen and uses its known modulus of elasticity to calculate its stress. Its calculated stress is the same as the residual stress in the test specimen.

Design engineers with the Magnavox Company in Fort Wayne, Indiana (54932) are attempting to develop an operational methodology for the concept. Their application concerns corrosion rate prediction for the structures produced by the company for ocean site installations. The prediction would be based on an existing large quantity of data relating the corrosion rate and the residual stresses in metallic components of the structures and a nondestructive measurement of residual stresses in a new component.

Engineers with Metal Improvement Company in Carlstadt, New Jersey (27106) are investigating the NASA method for possible adoption to measure the compressive residual stresses introduced in metal components by shot peening. The company does shot peening as a commercial service to improve surface fatigue life of the component. If the engineering evaluation provides satisfactory results and the method is adopted, the company will have greatly improved the service and its saleability since the information is usually required by customers.

The Associated Spring Corporation in Bristol, Connecticut (26855) investigated the method and rejected it as requiring too much sophistication for testing springs. Arcoa, Incorporated, a consulting engineering firm in Phoenix, Arizona (26854), has tested a prototype

and found the method to be satisfactory. The evaluation data and the prototype are available for future consulting work.

Control Numbers

Tech Brief Number: 68-10378
NASA Center: Kennedy Space Center
PATT Case Numbers: 26854, 26855, 27106, 54932
TEF Number: 379
Date of Latest Information Used: June 10, 1971

1966 NONDESTRUCTIVE TESTING SYMPOSIUM
TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A number of NASA-developed nondestructive testing (NDT) methods and related equipment were described to government, industrial, and academic representatives attending the Second Technology Status and Trends Symposium on October 26-27, 1966 at the Marshall Space Flight Center. The symposium was an activity of the NASA Technology Utilization Program. The proceedings were published in 1967 as SP-5082, Nondestructive Testing: Trends and Techniques.

Several ultrasonic techniques were described and analyzed for testing adhesion and strength in composite materials, residual stresses in aluminum, and welds in aluminum. An X-ray method, axial transverse laminography, was presented which allows imaging of thin cross sections of multilayer printed circuits without sectioning the test sample. Two major pieces of equipment which were designed under contract to Marshall Space Flight Center, the X-ray television system and the fast scan infrared microscope, were described and compared to conventional systems of the same type. The symposium was completed with a discussion of the studies at Marshall related to the prediction of future trends in NDT based on anticipated requirements. The major goals for NDT were the achievement of complete assurance of hardware interrogation to the desired quality levels and the development of faster testing methods. A number of investigations related to these general goals were briefly described: ultrasonic imaging systems, solid-state radiographic imaging systems, neutron radiography, liquid crystal applications and smaller, more portable equipment. In each of the examples cited below, the transfer was initiated by the symposium; the transfer activity is now based on the published proceedings.

The Boulder, Colorado division of Automation Industries (57803) has used the SP since 1967 as a basis for judgement and a guide in testing and product development. This division does corporate and contractual research on NDT equipment and techniques. It also produces thermal and ultrasonic NDT devices. A manager in the division reported that in some areas of NDT, NASA accomplishments described at the symposium are still the state-of-the-art.

An engineer with the Tennessee Valley Authority in Chattanooga, Tennessee (56301) has adapted information on liquid crystals from the SP to develop techniques for measuring temperature differences in

power generating machinery such as turbines. The liquid crystals are used in places on the generators where thermocouples do not provide satisfactory results. The data provided by these techniques are used to monitor the machinery and to develop design modifications.

A professor in the metallurgical engineering department of the University of Missouri at Rolla (56302) has included technology from the SP and symposium in his course on nondestructive testing for seniors and first year graduate students. Approximately 200 students have taken the course since it was initiated in September 1967. The NASA material has provided almost ten percent of the course input.

The R & D laboratories of the Aluminum Company of America in New Kensington, Pennsylvania (57802) are using the SP as a reference book to develop new procedures for quality assurance inspection of aluminum alloy wrought products in the company's plants. These procedures involve the use of ultrasonics for testing residual stresses and welds, and for identifying defects produced by other forming processes. A spokesman reported that several of the company's standard testing methods were directly traceable to the SP, which provided from 10 to 30 percent of the input in developing the methodology.

Control Numbers

Special Publication Number:	SP-5082
NASA Center:	Marshall Space Flight Center
PATT Case Numbers:	56301, 56302, 57802, 57803
TEF Number:	381
Date of Latest Information Used:	July 19, 1971

FIBER OPTICS DETECT SURFACE IRREGULARITIES

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

In order to acquire a capability for detecting surface irregularities in a specific tube flare, Marshall Space Flight Center contracted with Metro Physics, Incorporated in Santa Barbara, California (30502) to develop a new sensing device. The invention, described in Tech Brief 69-10152, permits taking a large number of discrete dimensional measurements on very small areas with a single setting and an accuracy on the order of micro inches. The fiber optics sensor portion of the instrument consists of bundles of optically transmitting fibers with their ends arranged on the gauge in a pattern of measuring points. Each measuring point is composed of transmitting and receiving fibers. The transmitting fibers are joined to a common light source, and the receiving fibers have an independent light sensor. Light emitted from transmitting fibers reflects from the inspected surface to the receiving fibers. The amount of light reflected is a measure of the distance between the measured surface and the end of the bundle. The rest of the unit consists of electronics for activating the fiber optics, for activating the scanning functions, for receiving, amplifying, and displaying the scanned data on a cathode ray tube, and for determining the distance being sensed and the deviation from standard.

As a result of its work in developing the device, Metro Physics has been able to further develop a commercial product. Great interest in the instrument has been shown by machine tool manufacturers, since it can check contours, measure critical part dimensions, measure surface flatness and finish, measure holes and measure deflection. To date only custom-built units have been sold, but Metro will soon begin mass production of the device as a result of the response to a recent advertising campaign. This will significantly reduce the present price of $1,200 and greatly increase its marketability.

In an unusual application attempt, the firm is working with NASA's Technology Application Team at the Illinois Institute of Technology Research Institute in Chicago to modify the instrument for use in detecting indented writing (i.e., impressions made on backing sheets or pages of a pad under the sheet upon which someone has written).

The Law Enforcement Assistance Administration and several police departments are active in this adaptation of space program technology.

Control Numbers

Tech Brief Number: 69-10152
NASA Center: Marshall Space Flight Center
PATT Case Number: 30502
TEF Number: 331
Date of Latest Information Used: July 29, 1971

OPTICAL STRAIN MEASURING DEVICE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A noncontacting-strain-measuring gauge and extensometer for remotely measuring the mechanical displacement along the entire length of a test specimen was developed at the Jet Propulsion Laboratory under contract to the NASA Pasadena Office. It consists of an optical system which continuously senses and records the displacement of reflective bench marks on a test specimen when the specimen is subjected to stress. This displacement is directly related to the strain in the specimen. The sensing is done by means of a light source, a photocell, and a combination of lens and mirror. The photocell signals are electrically amplified and reproduced on a cathode ray tube and a strip chart recorder.

Engineers at the Bell Telephone Laboratories in Holmdel, New Jersey (53850) have developed several minor design modifications of this strain measuring device, and a prototype is planned. If the prototype tests are satisfactory, the device will be used for in-house automated testing of microelectronic components. According to a Bell engineer, the NASA invention appears to be very well suited to this application, and its use will allow a substantial savings in quality control inspection costs.

Control Numbers

Tech Brief Number: 70-10292
NASA Center: NASA Pasadena Office
PATT Case Number: 53850
TEF Number: 383
Date of Latest Information Used: March 27, 1972

SONIC IMPEDANCE NDT

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The problem of detecting voids in polyurethane foam insulation layers has resisted solution by many attempted NDT methods, including microwave, X-ray, neutron radiography, ultrasonics, electrostatic field intensity, low-frequency sound velocity, sonic-brush noise generation and microphone pickup, and optical absorptance/reflectance. These methods are either very costly or insufficiently sensitive.

SPACO, Incorporated, under contract to Marshall Space Flight Center, developed a sonic impedance method to detect voids and unbonded regions in the layers as small as one inch in diameter and 0.03-inch thick. Sonic impedance occurs when an acoustical signal is damped by solid, well-bonded foam; the absence of this damping indicates a flaw. The NASA technique may be performed manually or automatically with a transducer even through a protective coating on the test object. The readout can be made directly by meter or recorder, which eliminates subjective evaluation by the operator. The discovery was announced in a 1970 Tech Brief.

The product development division of a major corporation (48782) was planning to include the sonic impedance technique in production line quality control specifications for a potential new product if the market studies related to it were favorable. The planned product was a sandwich panel of two plastic forms separated by polyurethane foam to be used in boats and campers. If the foam and plastic are not properly bonded, lengthy exposure to sunlight will produce blisters in the plastic. Prior to receiving this NASA technology, the lack of a production quality control method for the panels presented a serious problem to its marketability. In December 1971, the corporation closed down the facility that was developing the panel product. There are no further plans to use the NASA technology.

Control Numbers

Tech Brief Number: 70-10012
NASA Center: Marshall Space Flight Center
PATT Case Number: 48782
TEF Number: 376
Date of Latest Information Used: March 27, 1972

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INFRARED SCANNER FOR NONDESTRUCTIVE TESTING

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

In the mid-1960's, Raytheon Company developed an operational infrared scanning microscope system for automated nondestructive testing of electronic components, under contract to NASA's Marshall Space Flight Center. The unit, which Raytheon called the Compare System, included the results of previous research funded in-house and by the Defense Department. The Compare System incorporated computer processing and storage capabilities with high sensitivity, fast detector response, and good resolution on the real-time cathode ray tube display. Thermal infrared profiles for semi-conductor chips, transistors, and integrated circuits can be measured and plotted with the Compare System. An analysis of each profile yields valuable information on electrical and physical properties for design improvement and quality control of the electronic component tested.

Several Raytheon engineers who had helped develop the technology founded Dynarad, Incorporated in Norwood, Massachusetts (70001) in 1968. Dynarad then purchased all of Raytheon's rights related to infrared nondestructive testing, together with Raytheon's prototype model of the Compare System. With in-house funds, Dynarad miniaturized the system to make it portable, redesigned the scanning device, incorporated a variety of detectors to provide different infrared channels for different applications, and made several other refinements on the Compare System design. As a result of these developments, Dynarad introduced two products on the commercial market in 1971: the Fast Scan Infrared Camera and the Fast Scan Infrared Microscope. In the first year, 33 Fast Scan Infrared Cameras were sold at prices ranging from $18,900 to $26,700. The cameras are being used for nondestructive testing of electronic circuits, void detection in honeycomb construction, gas laser research, and automobile tire design testing. They are being evaluated by potential customers for computer-automated, assembly line quality control for automobile radiators and tires.

The NASA development contract with Raytheon included a test program to study the potentially destructive phenomenon of second breakdown in bipolar power transistors. In 1971, NASA published Tech Brief 71-10022 which described the fast scan infrared detection and measurement instrument and Tech Brief 71-10021 which described the test program results from using the instrument.

Perkin-Elmer Corporation in Pomona, California (57574) used the TSP for Tech Brief 71-10021 to establish test procedures for a power transistor component used in several of the company's mass spectrometer products. As a result of the tests, the transistor was found to be prone to second breakdown and was subsequently replaced in the products. By eliminating this cause for equipment failure, Perkin-Elmer is saving time, money and reputation. The need and technique for testing power transistors for second breakdown is now a part of the company's engineering expertise and will probably be used in the future.

Control Numbers

Tech Brief Numbers: 71-10021, 71-10022
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 57574, 70001
TEF Number: 398
Date of Latest Information Used: January 18, 1972

NONDESTRUCTIVE TESTING MANUALS

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Quality control in large volume production is usually conducted by statistically sampling the output, with acceptance contingent upon finding a predetermined minimum number of defects. For space applications, however, defects are not permissible; and statistical sampling is not a feasible method of quality control. Every item must be assured reliable, with maximum confidence in its integrity. In addition, when using conventional strength tests, a material is subjected to stresses and loads to the point of failure, following which the tested item is no longer usable. Nondestructive testing permits evaluation of every item of output without damage to the material. NDT is thus a necessary procedure for accepting materials for space use.

Applications of available NDT technology have been limited due to the scarcity of information and instructional materials for training technicians. NASA acted to solve this problem by contracting with the Convair Division of General Dynamics to develop a set of training handbooks. The finished product includes three volumes on eddy current testing (TB 67-10374), two volumes on magnetic particle testing (TB 68-10391), four volumes on ultrasonics (TB 69-10108), two volumes on liquid penetrant testing (TB 69-10278), and six volumes on radiographic testing (TB 71-10156). For each type of NDT, at least one volume is in a programmed instruction format through which a student progresses by making selective path choices concerning the validity of each of a series of statements arranged in a sequence of increasing difficulty and comprehensiveness. The other volumes are in standard text format; they contain a comprehensive comparison of NDT methods with specific details on the capabilities and limitations of each method for particular defects.

Convair (53871) is now publishing and selling a set of manuals which are almost identical to the NASA TSP's. The company has also developed a training course based on the material. The American Society for Nondestructive Testing (ASNT) has sold more than $230,000 worth of the manuals published by Convair to buyers in 42 countries. Convair's $600, three-week NDT course was begun in July 1967. Since then, more than 600 supervisory engineering personnel have attended. Convair has invested $250,000 in its teaching facility for the short course.

Eddy current testing is based on the interaction between magnetic fields and electrical currents. An inductance coil is placed near the surface of a test object which must be fabricated from an electrically conducting material. The coil's alternating current produces a magnetic field and associated electrical eddy currents inside the object. Internal flaws affect the magnetic field which, in turn, affects the coil's current; this last effect is registered on an indicator. Dover Corporation in Memphis, Tennessee (5170) used the NASA handbooks to train two NDT technicians who test the quality of purchased materials. Use of the books saved the firm about $2,000 per man trained. Frank D. Weaver & Associates, engineering consultants in Houston, Texas (6706), uses eddy current testing for pipeline materials. The NASA handbooks provided the company's capability in eddy current testing; a literature search capable of yielding equivalent information would have cost about $2,000 and probably would not have been undertaken.

Magnetic particle tests can be performed on finished components, billets, hot rolled bars, and forgings by magnetizing the test specimen, applying the magnetic particles, and interpreting the pattern formed by the particles. National Castings in Cleveland, Ohio (27624) used the manuals to convince a customer of the effectiveness of this kind of NDT, which resulted in lower manufacturing costs. The company also trains its NDT inspectors with the manuals. A Midwestern tool company's (27634) chief metallurgist and his staff studied the handbooks to ascertain the firm's equipment needs and to justify the capital outlays for the equipment necessary to perform magnetic particle NDT. Manufacturing costs have since been decreased because defective parts are now identified early in the production process through magnetic particle NDT. Kaufman Fabricators, Incorporated in Kaufman, Texas (27642) trained a foreman to perform magnetic particle NDT by using the NASA documents. The company was thus enabled to complete with confidence two unusual jobs requiring three-inch plate welding and fabrication of certain contours by cutting and welding in lieu of bending the material. Allied Structural Steel Company in Hammond, Indiana (27744) saved $1,500 in training costs with the manuals. Prior to establishing its internal NDT expertise, the firm had hired outside technicians to perform NDT on large structural welds, and encountered severe problems of coordinating the availability of the technicians with its own production schedule. The major benefit of using the NASA manuals is the increased efficiency possible with having their own employees qualified and available to perform the tests. The General Electric Company's Large

Generator and Motor Department in Schenectady, New York (31534) established a training program for NDT engineers. The instructor drew more than half the material from the magnetic particle handbooks. He estimated that a savings of 25 hours of his time could be attributed to use of the manuals in preparing the first course for 21 engineers.

Liquid penetrant testing is the oldest and most widely used NDT method. It can be used to detect surface discontinuities in nonporous metallic and nonmetallic products, such as welds, forgings, castings, and plastics and ceramics. Capillary action, which elevates or depresses the surface of a liquid in contact with a small discontinuity in a solid, constitutes the basic physical principle for liquid penetrant testing. A liquid with low tension and high capillarity is applied to a test specimen and allowed to penetrate discontinuities. Subsequent removal of the liquid from the surface leaves liquid in the discontinuities, and a blotting action "developer" is applied to indicate the location of the discontinuity. Visibility of the indication is enhanced by adding dyes to the liquid before application. Beech Aircraft Corporation in Wichita, Kansas (40622) has trained eighty quality control inspectors in liquid penetrant testing by using the manuals as both course texts and reference sources.

Ultrasonic testing is a rapid and economical method for detecting flaws by measuring echoes and converting the measurement to an indicator of flaws. Radiography is an old and well known method, encompassing X-ray, gamma-ray, neutron radiography, radiation backscatter and fluoroscopy. Most companies use several NDT methods in receiving inspection, assembly line quality control and equipment monitoring. In such cases the complete collection of training handbooks is usually purchased. The senior NDT consultant for Mobil Oil Company's Research and Development Branch in Paulsborough, New Jersey (53789) reviewed the complete set of NASA manuals and recommended their use in an article prepared for Mobil's monthly newsletter. As a result, NDT instructors at Mobil's refineries are using the manuals to train new employees for NDT they will perform on refinery production equipment. Use of the manuals saves time and makes possible a more thorough introductory course. A large Eastern firm is using the NASA documents and other information on the various NDT methods to aid in its equipment design and materials purchasing. A proper method for each problem is selected, and the required tests are performed to aid the firm in securing high quality equipment at minimum cost. The major benefit achieved, as is the case for most large

companies which use the entire set of manuals, is the ability to use safely materials at a high proportion of their ultimate strength and thereby reduce costs. A yearly savings of $1,000,000 is attributed to use of the NASA information by this proprietary company.

The ASNT carries an advertisement for the Convair manuals in the Society's monthly publication, which states that they are "the most complete and comprehensive set of training manuals ever offered for NDT personnel." Most of the volumes sold by ASNT are in one of two sets: programmed instruction volumes for all five methods or reference volumes for all five methods. To date, the Society has sold more than 1,400 of the former sets at $125.50 per set and more than 1,800 of the latter sets at $30.50 per set.

Control Numbers

Tech Brief Numbers:	67-10374, 68-10391, 69-10108, 69-10278, 71-10156
NASA Center:	Marshall Space Flight Center
PATT Case Numbers:	5170, 6706, 27624, 27634, 27642, 27744, 31534, 40622, 53789, 53871
TEF Numbers:	14, 261, 374, 375, 377

Date of Latest Information Used: May 20, 1971

NONDESTRUCTIVE TESTING OF BRAZED COMPONENTS

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Welded and brazed joints on space vehicles must withstand severe operational stresses, including vibration, large mechanical loading and extremes of temperature. A variety of nondestructive tests are used to verify the integrity of brazed joints, some of which are specifically useful for certain materials, geometries and joint accessibility. A study of radiographic, ultrasonic, thermographic, and leak tests was conducted by North American Rockwell Corporation under a Marshall Space Flight Center contract. The illustrated report, available as TSP 68-10394, gives the results of the study, descriptions of some unique methods and equipment, and summary tables of the advantages and limitations of the various NDT methods for brazed components.

The Tenneco Hydrocarbon Chemicals Division of Tenneco Chemicals, Incorporated in Pasadena, Texas (27305) reviewed the TSP to verify the feasibility of joining techniques that may enable the firm to reclaim blocks used in acetylene production. Blocks damaged during the combustion-manufacturing process may be reclaimed by bonding a three-inch plate to the damaged surface; such reclamation of the blocks may save the firm $70,000 per year.

Homelite Division of Textron, Incorporated in Port Chester, New York (24342) is attempting to develop a nondestructive test from technology presented in the TSP for the brazed joint in one of its products. A preliminary investigation indicated that the techniques described in the document could probably be used to solve a quality assurance problem in the company's chain saws. The brazed joint, which connects the clutch drum and the chain sprocket, separates during use in an undesirable percentage of the saws and must be replaced under warranty. A company spokesman reported that the development of a good quality assurance method on this particular joint will solve a nuisance problem for the company. Homelite's metallurgical and quality assurance personnel have the NASA document now and will soon proceed to adapt technology from it.

The National Business Aircraft Association, Incorporated (NBAA) in Washington, D.C. (24833) is an association of companies which operate aircraft as an adjunct to their normal business. The association staff provides state-of-the-art information and technical

assistance to member companies for the purposes of increasing efficiency and reducing costs. As part of this function, the staff has sent the TSP to the NBAA technical committee and to aircraft maintenance personnel at the two airports in the country with the largest number of business aircraft.

Control Numbers

Tech Brief Number: 68-10394
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 24342, 24833, 27305
TEF Number: 264
Date of Latest Information Used: July 16, 1971

NONDESTRUCTIVE TESTING OF HONEYCOMB STRUCTURES

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A research program was conducted at North American Aviation, under contract to Marshall Space Flight Center, to discover a means of detecting disbonds in composite structures. From theoretical and test data, a relationship was established between bond strength and the vibratory response of face sheets of honeycomb composite panels. Valid parameters were determined for the ultrasonic measurements of the bond strength of organic adhesives. From this information, various methods of bond strength determination were proposed, of which the automatic DOT (Driver-Displacement Oriented Transducer) method appears most applicable to both the lap shear type application and the honeycomb sandwich structures. The system has the distinct advantage of providing noncontact bond strength measurements. Four types of honeycomb composite structures were fabricated to provide reference standards for evaluating both the ultrasonic techniques and the scanning/recording system. Deliberate disbonds, in the shape of triangles or squares, were located at predetermined interfaces on the honeycomb panels. Based on the results of a comprehensive literature survey, five basic ultrasonic techniques were chosen as potential solutions for the honeycomb composite inspection problem. To evaluate these techniques, five breadboard systems were developed and tested: pulse-echo interference, impedance, decrement, spectrum analysis, and intermodulation. The impedance system showed the most promise, and further development resulted in the successful detection and recording of disbonds in the specimens. A number of semiautomated scanning/recording systems were developed to supplement the ultrasonic technique evaluation. An advanced, fully automated system was integrated with the ultrasonic detection system. This combined system (the DOT method) was characterized for transducer and circuit specifications, and operating instructions were prepared. The results of this research program were announced in Tech Brief 67-10574.

Southwest Research Institute in San Antonio, Texas (4303) is using the TSP to reduce costs on a research project involving hydrostatic pressure tests of deep ocean pressure vessels to evaluate different vessel designs. The vessels are made with a honeycomb structure. If the vessel ruptures during tests as a result of poor bonding, a production flaw, the vessel has been wasted since this

provides no information for design evaluation. To prevent this waste, the NASA technology is used to scan ultrasonically and to analyze areas of poor bonding which are then repaired before pressure testing.

Control Numbers

Tech Brief Number: 67-10574
NASA Center: Marshall Space Flight Center
PATT Case Number: 4303
TEF Number: 385
Date of Latest Information Used: July 9, 1971

STRAIN GAGE INSTALLATION MANUAL

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Detailed specifications for installing laboratory strain gages have been compiled into a handy reference manual, TSP 70-10715, by North American Rockwell Corporation under contract to Marshall Space Flight Center. The manual provides laboratory technicians with a ready source of instructions on the techniques and procedures for cementing a wide variety of strain gages onto most of the commonly encountered engineering materials. Materials covered include various steels, aluminum, titanium, beryllium, magnesium, copper, ceramics, plastics and graphite. The manual is presented in two major sections. The first gives detailed instructions for preparing surfaces of the various materials for strain gage installation. Specific note is made of any health or safety hazards presented by the materials. The second section gives detailed procedures for installing various types of strain gages using a variety of conventional bonding agents.

Technicians at Continental Testing Laboratories, Incorporated in Fern Park, Florida (51950) are trained to install strain gages on test objects with the NASA manual. Continental performs a variety of tests, including several for strain, on electronic components and electromechanical systems as a contract service. The manual is also used as a reference for solving particular problems which arise in the course of installing strain gages.

Motorola, Incorporated in Scottsdale, Arizona (52304) has used information from the manual on a contract job in which they installed strain gages on the jet engine compressor blades produced by another company. Tests were then conducted on the blades by their producer. The manual is also used for strain gage installation on Motorola's products. The information on particular techniques, cleaning procedures, and maintenance of the cleaned surface are particularly important to Motorola testing personnel.

Medical researchers at Temple University in Philadelphia, Pennsylvania (51572) have used a procedure from the manual to construct a device for heart research on test animals. The device consisted

of a metal sheet with strain gages attached to it, which was then wrapped around the animal's heart. Without interfering with the heart's function, it provided data on the heart's relative stroke volume output.

Control Numbers

Tech Brief Number: 70-10715
NASA Center: Marshall Space Flight Center
PATENT Case Numbers: 51572, 51950, 52304
TEF Number: 384
Date of Latest Information Used: July 13, 1971

APPENDIX B

Summaries of Technology Transfer Reports Involving
NASA-Generated Visual Display Systems Technology

SUMMARIES OF TECHNOLOGY TRANSFER REPORTS INVOLVING

NASA-GENERATED VISUAL DISPLAY SYSTEMS TECHNOLOGY

NASA CONTRIBUTIONS	TRANSFER STAGES							
	Awareness		Evaluation		Prototype		Diffusion	
	Cont.	Term.*	Cont.	Term.	Cont.	Term.	Cont.	Term.
• Automated Patient Monitoring System		16960**					62401	
• Computer Display System							76502	
• ECG Monitoring With Contourograph Display					43946 47118			
• Improved EEG Monitoring Method			56247					
• Infrared Scanner for Nondestructive Testing					57574		70001	
• NASTRAN***								
• Optical-Data Processing Handbook					17080 21368 35410 49588 59960			
• PERT Vertical Chart Display			35868					
• Phototransistor Mosaic					76501			
• Single Gun Color CRT	57800		58036 58896			57882		
• Surface Temperature Mapping With IR Photo Pyrometry			42606					
• The General Electric Computed Color TV Display			64102		64101			
• Universal Control and Display Console					63801			
• Videofile							66201	
• Vis-a-Plan Management Technique				23570	5054 5067	28862		
• Visual Display Panel and Computer Input/Output Device	58894		55508 57912					
• Weather Satellite Image Display					78001 78002		431	

* The action status, continuing or terminated, of transfer cases at the time DRI-TRIS contacted users. Cases are classed as terminated when [a] no further adaptation or adoption is contemplated, [b] a better technical alternative has been found, or [c] continued transfer activity is not economically feasible.

** Numbers in columns refer to TRIS case numbers.

*** This Technology Transfer Example Summary is based on a report by Computer Sciences Corporation, entitled NASTRAN Benefits Analysis. No TRIS cases are involved.

AUTOMATED PATIENT MONITORING SYSTEM

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The Boeing Company, under contract to NASA's Marshall Space Flight Center, developed a radio-linked patient monitoring system that is capable of collecting several channels of physiological data from as many as 64 hospital patients and transmitting the data to a central control station. The information is transmitted in digital form and is directly processed by a computer. Battery-operated patient units consist of small strap-on electronics packages weighing less than one pound, enabling their use on ambulatory as well as bedridden patients. A typical unit contains four EKG electrodes, two thermistors for temperature measurement, and a strain gage to monitor blood pressure. A unique characteristic of the Boeing system is its "interrogation" mode of data transmission. Using a single frequency for the central station and patient units, the system allows input of data from each patient only upon interrogation from the central station, which occurs at regular intervals, allowing a two-second transmission from each patient in turn. In the "single patient" mode, any patient can be continuously monitored by setting a selector switch in the central station. The Boeing system was announced by NASA in a 1968 Tech Brief.

Peter Petroff, who had been associated with Marshall's contract monitoring duties, left NASA in 1969 to form his own company, Care Electronics in Huntsville, Alabama [62401], which is producing a modified version of the monitoring system. Based partly on the Boeing design and significantly on telemetry technology from the NIMBUS program, Petroff's system continuously monitors EKG, blood pressure, and temperature of four patients using a PCM-FM telemetry method which provides signals free of static and other interference. His system interfaces directly with computers. The interference-free transmission allows insertion of control limits for alarm systems, with the assurance that an alarm is triggered only by a physiological emergency. First-year sales of the system were $980,000; second-year sales projections of $2.9 million were realized; and four regional sales offices were opened during 1971. Petroff estimates that if it had been necessary to duplicate the NIMBUS technology, the cost would have been approximately $500,000 to $600,000. He also found that the performance and construction specifications for the Boeing system were excessively expensive for the existing market. The very high reliability levels in the NASA specifications [e.g., 98 percent] cost about three

times more to achieve than a lower level [93 percent] acceptable for this commercial product.

Honeywell, Incorporated in Denver, Colorado [16960] has had a patient monitoring system on the market for several years which provides a continuous, permanent EKG and blood pressure record. Research engineers at Honeywell reviewed the TSP for potential modifications of the company's product. Although the NASA technology offered a new approach to biotelemetry, the engineers concluded that major product changes would not be cost effective. They have no further interest in the TSP.

Control Numbers

Tech Brief Number: 68-10131
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 16960, 62401
TEF Number: 116
Date of Latest Information Used: March 30, 1972

COMPUTER DISPLAY SYSTEM

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

In 1964, functional requirements anticipated for the Saturn V pre-launch checkout operations called for unique computer input/output capabilities. Provisions were included for intermixing and overlaying closed-circuit TV data and computer-generated lines/characters at the display face; automatic and rapid accessing [by the CCTV subsystem] of a large 35mm checkout data slide bank; and a multiterminal system configuration. These capabilities were not available in an integrated way in existing display systems at the time.

Sanders Associates, Incorporated [76502], in 1965, received a NASA contract to develop the Saturn V Operational Display System for the large-scale digital systems [RCA 110A] at each of seven installations at Kennedy Spacecraft Center and Marshall Space Flight Center. During the two-year development phase, an input/output console was designed to provide [1] a high-capacity logical interface between the RCA 110A and the display, and [2] a unique dual-mode cathode ray tube deflection system. At the time, the latter represented a significant advancement in CRT state-of-the-art in that it combined the wide bandwidth, low power requirements of line and character generation with the narrow bandwidth, high power essential to precise registration [at the scope face] of intermixed CCTV and computer-generated data. Critical to these requirements was a beam deflection yoke specifically designed for this application.

After the design-development phase was completed, the fifty engineers and technicians of the Data Display Systems Department engaged in the Saturn V effort were reassigned to an internally funded project to develop a commercial equivalent of the NASA system. Utilizing the Saturn V system as a prototype, redesign was undertaken to [1] provide operational compatibility with a broad range of commercially available digital processing systems; [2] decrease the burden imposed on the computer by line and symbol generation; [3] simplify the computer-display interface; [4] provide "centralized" character and line generation; and [5] broaden the variety of data control and entry, indicator, and recording devices available at the display console.

As a result of this effort, a display processor, display generator, and series of consoles were developed during 1966-68 and subsequently marketed. Sanders' ADDS/900 System series, for example, is recognized as unequalled in display capacity and flexibility. Twenty-eight of these systems have since been delivered to a broad range of federal and commercial organizations, both domestic

and foreign, with applications in computer-aided design, flight simulation/pilot training [DC-10], real-time flight test monitoring and air traffic control. The base price for an ADDS/900 System is approximately $70,000.

McDonnell-Douglas used one of Sanders' display systems in flight testing the new DC-10 in 1970. For this application, a $3.5 million automated data handling system was provided by Xerox Data Systems, which included a $700,000 Sanders Display system as part of the package. One benefit of the automated data handling was a reduction in total flight test time from a projected 2,000 hours to 1,250 hours.

Using the same technology, Sanders developed another display system called CLINI-CALL, a medical data management system. Hospital data management problems are increasing as a result of more admissions, shorter stay times per patient, more laboratory instruments and tests, and more inputs to diagnosis. The Sanders system stores, retrieves, routes, and checks such data; it provides patient medical histories and current medical records, statistical summaries, and legal records; it also schedules medical tests and keeps inventories of supplies and bed availability. Remote terminals in key locations allow easy access to the computer by authorized personnel. The Mayo Clinic installed CLINI-CALL displays in 1971 to manage accounting and admissions data. A seven-year backlog in these records was brought up-to-date in thirty days. Other hospitals installing the system include Kaiser Memorial Hospital in San Francisco and Walter Reed Hospital in Washington, D. C.

Sanders' management credits the Saturn V Operational Display System project with significant advancement in the state-of-the-art; in providing for the development of an unequalled, in-house [Sanders'] capability in display system design; and in providing a functional engineering prototype from which a commercial system of expanded capability, efficiency and lower cost emerged.

This example traces the manner in which a stringent aerospace requirement accelerated the development of industrial technological expertise; and, subsequently, how an internal, lateral transfer of such expertise resulted in successful commercial product activities.

Control Numbers

Tech Brief Number:	None
NASA Centers:	Kennedy Spacecraft Center; Marshall Space Flight Center
PATT Case Number:	76502
TEF Number:	99

Date of Latest Information Used: February 16, 1972

ECG MONITORING WITH CONTOUROGRAPH DISPLAY

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A new biomedical display system, developed for the NASA Manned Spacecraft Center by Technology, Incorporated, was the subject of Tech Brief 70-10030. The system was devised for real-time presentation of an electrocardiogram [ECG] in a three-dimensional form. The ECG is displayed as a contourogram on the cathode ray tube of a variable-persistence oscilloscope. Successive ECG cycles are stacked below their predecessors, which achieves the three-dimensional effect; a major change in the ECG signal markedly alters the contourogram pattern. The three-diniensional effect is accentuated by dynamically modulating trace intensity so that ECG peaks are brighter than the baseline.

A research associate in the Department of Logopedics at Wichita State University in Wichita, Kansas [47118] has constructed a demonstration model of the contourograph display system. It is now available for use whenever a pertinent research problem arises.

A professor of Veterinary Medicine and Bioengineering at the University of Missouri in Columbia [43946] has built a laboratory model of the display for his research on post-surgical erythmia in animals. A means of recording data so that every ECG complex did not have to be studied in real time was needed. The professor acquired the NASA TSP and adapted the concept for operation with magnetic tape and a computer interface to permit digitizing and storage of the data. The adaptation also reduced equipment requirements.

Control Numbers

Tech Brief Number: 70-10030
NASA Center: Manned Spacecraft Center
PATT Case Numbers: 43946, 47118
TEF Number: 390
Date of Latest Information Used: September 30, 1971

IMPROVED EEG MONITORING METHOD

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The commercially available instrumentation for monitoring brain waves typically uses only 10 probes per hemisphere and monitors only passive signals to produce amplified data in strip chart form. The data must then be interpreted by highly trained personnel, and is limited in that only massive tumors or lesions can be detected.

R. L. Trent of Electronics Research Center published his conceptualization of an improved system of EEG sensing and display in TB 70-10447. The system would overcome the limitations of conventional systems by increasing the number of probes to 25 or 50 per hemisphere and mounting microelectronic preamplifiers adjacent to the probe contact points. The probes would be mounted in a fixed array in a semiflexible plastic housing incorporating a shielding ground plane to prevent radio frequency interference. This sensing system would more precisely locate small tumors or lesions with greater gain factors, resulting in improved sensitivity and signal-to-noise margins. The display system replaces the strip chart display by very rapid sampling of data from each channel and then converting the data to binary digit form for storage in a computer memory. Subsequent introduction of a perturbing input is followed by resampling of each channel's data, which are compared by the computer with the original signals. Differences are displayed on a CRT along with the signal waveforms.

Tek-Dayme Research Associates in Carbondale, Illinois [56247] is building a prototype unit of Trent's system for the University of California Medical School. The working model should be well developed within six months.

Control Numbers

Tech Brief Number: 70-10447
NASA Center: Electronics Research Center
PATT Case Number: 56247
TEF Number: 392
Date of Latest Information Used: November 22, 1971

INFRARED SCANNER FOR NONDESTRUCTIVE TESTING

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

In the mid-1960's, Raytheon Company developed an operational infrared scanning microscope system for automated nondestructive testing of electronic components, under contract to NASA's Marshall Space Flight Center. The unit, which Raytheon called the Compare System, included the results of previous research funded in-house and by the Defense Department. The Compare System incorporated computer processing and storage capabilities with high sensitivity, fast detector response, and good resolution on the real-time cathode ray tube display. Thermal infrared profiles for semi-conductor chips, transistors, and integrated circuits can be measured and plotted with the Compare System. An analysis of each profile yields valuable information on electrical and physical properties for design improvement and quality control of the electronic component tested.

Several Raytheon engineers who had helped develop the technology founded Dynarad, Incorporated in Norwood, Massachusetts [70001] in 1968. Dynarad then purchased all of Raytheon's rights related to infrared nondestructive testing, together with Raytheon's prototype model of the Compare System. With in-house funds, Dynarad miniaturized the system to make it portable, redesigned the scanning device, incorporated a variety of detectors to provide different infrared channels for different applications, and made several other refinements on the Compare System design. As a result of these developments, Dynarad introduced two products on the commercial market in 1971: the Fast Scan Infrared Camera and the Fast Scan Infrared Microscope. In the first year, 33 Fast Scan Infrared Cameras were sold at prices ranging from $18,900 to $26,700. The cameras are being used for nondestructive testing of electronic circuits, void detection in honeycomb construction, gas laser research, and automobile tire design testing. They are being evaluated by potential customers for computer-automated, assembly line quality control for automobile radiators and tires.

The NASA development contract with Raytheon included a test program to study the potentially destructive phenomenon of second breakdown in bipolar power transistors. In 1971, NASA published Tech Brief 71-10022 which described the fast scan infrared detection and measurement instrument and Tech Brief 71-10021 which described the test program results from using the instrument.

Perkin-Elmer Corporation in Pomona, California [57574] used the TSP for Tech Brief 71-10021 to establish test procedures for a power transistor component used in several of the company's mass spectrometer products. As a result of the tests, the transistor was

found to be prone to second breakdown and was subsequently replaced in the products. By eliminating this cause for equipment failure, Perkin-Elmer is saving time, money and reputation. The need and technique for testing power transistors for second breakdown is now a part of the company's engineering expertise and will probably be used in the future.

Control Numbers

Tech Brief Numbers: 71-10021, 71-10022
NASA Center: Marshall Space Flight Center
PATT Case Numbers: 57574, 70001
TEF Number: 398
Date of Latest Information Used: January 18, 1972

NASTRAN

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The NASA Structural Analysis Program [NASTRAN] is a general purpose, digital computer program designed to analyze static and dynamic behavior of elastic structures and to display a summary of the computed structural behavior with standard computer plotters. The program was, and still is, used by NASA and aerospace companies to design and analyze aircraft fuselages, wings and tail assemblies, space vehicles [Viking and Skylab] and their related launch facilities, and turbine engines.

The wide range of analytic capability built into NASTRAN includes: static structural response to concentrated and distributed loads; thermal expansion and enforced deformation; dynamic structural response to transient loads; steady-state harmonic loads and random excitation; and determination of real and complex eigenvalues for use in vibration analysis, dynamic stability analysis and elastic stability analysis. The program is highly user-oriented through an easy data input format, error message vocabulary, and annotated, modular output format. The output plotting may be selected from a variety of structural and curve plotting options. NASTRAN can handle structural problems of virtually unlimited size.

Between 1965 and 1970, Goddard Space Flight Center developed the program through a combination of in-house and contracted research for approximately $3,000,000. Five Special Publications resulted, which describe different aspects of NASTRAN: SP-260, SP-221, SP-222, SP-223, and SP-224. The first document, SP-260, is a general summary of NASTRAN functions and capabilities; the other four describe the theory, use, programming, and sample problems related to it. After Goddard programmers and engineers completed NASTRAN's development, it was released to public users in November 1970. The program, as is the case with most NASA computer programs, is being disseminated at cost by the Computer Software Management and Information Center [COSMIC] at the University of Georgia, under contract to NASA. A set of NASTRAN tapes and documentation can be purchased from COSMIC for an average cost of $1,700, depending on the options required by the user. The NASTRAN Systems Management Office [NSMO] was established at NASA's Langley Research Center to provide users with essentially free program maintenance services. NSMO operates on an annual budget of about $400,000.

An extensive analysis of NASTRAN benefits was recently conducted by Computer Sciences Corporation [CSC] under contract to Goddard. A sample of 205 NASTRAN users was surveyed by mail questionnaires, telephone interviews and personal interviews. The

initial mailing resulted in 152 responses, which identified 186 current applications and an additional 55 more in the planning stage. This Transfer Example File Summary is based on CSC's final report, entitled NASTRAN Benefits Analysis.

For most NASTRAN users, the primary benefit has been a substantial reduction in real operating costs and, therefore, a great increase in productivity. Based on the CSC study, five important factors contributing to this benefit were: analyses were accomplished which could not have been done without NASTRAN; more complete and accurate results were attained; development time was shortened; communication between engineers and programmers was improved; and cost of analysis was reduced. Ford Motor Company, for example, is saving an estimated $12,000,000 annually by using NASTRAN for quality assurance analysis of automobile frames. A nonaerospace company has used it to save an estimated $5,000,000 of the costs for new product development. A commercial service bureau has an annual revenue of $240,000 from applications of the NASTRAN program. Nonaerospace applications for industrial and service bureau users included examples such as large buildings, machinery structures, high-speed railroad tracks, trussed structures, electronic products, shell structures and vessel support structures. Two-thirds of the 186 applications would not have been attempted without NASTRAN.

Based on the survey data, the following benefits were summarized in the CSC report:

> NASTRAN is considered to be vital to the structural analysis community. Two-thirds of current NASTRAN applications would not have been attempted without it.
>
> Users have spent an estimated $1,732,000 to apply and improve NASTRAN.
>
> Total annual savings estimated by all respondents of the CSC survey exceeded $14.5 million; and NASTRAN was contributing to new product developments valued at more than $5.6 million.
>
> Services based on NASTRAN are generating more than $240,000 in new business annually.
>
> 667 persons, primarily engineers, were using NASTRAN at the time the study was undertaken.

These figures compare favorably with NASA's development and operating costs.

Control Numbers

Tech Brief Number: None
NASA Centers: Goddard Space Flight Center; Langley Research Center
PATT Case Number: None
TEF Number: 410
Date of Latest Information Used: February 15, 1972

OPTICAL-DATA PROCESSING HANDBOOK

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Despite the existence of abundant literature on all aspects of optical-data processing, persons with only a general technical background may experience great difficulty in becoming familiar with the field because most of the literature is written at highly advanced levels. In order to fill a recognized need for an introductory exposition of the basic principles of optical-data processing, including optics, photography, electronics, holography, and other matters, A. R. Shulman of NASA's Goddard Space Flight Center compiled a self-teaching text which gives readers an overview of the subject. Mathematical discussions are presented; however, a basic understanding can be gained without reliance on those sections. In March 1968, NASA announced the handbook's availability through Tech Brief 68-10069, "Principles of Optical-Data Processing Techniques." To date, NASA has received over 1,000 requests for the TSP.

Engineers with Grumman Aerospace Corporation in Bethpage, New York [35410] refer to the TSP on a daily basis for information relevant to their development of commercial and aerospace optical-data processing systems. A Grumman engineer reported that the NASA document has provided information which was quite important in solving development problems.

The TSP has been widely circulated at the Sperry Rand Research Center in Sudbury, Massachusetts [21368]. Several researchers regularly use the document for reference purposes and, in one instance, saved over $5,000 of the developmental costs for a computer-linked radar product.

A graduate student in physics at Cornell University in Ithaca, New York [17080] realized a significant time savings in his doctoral research by using the TSP to set up his experiments on metal defects. He used one of the optical-data processing techniques in conjunction with a computer to record and analyze the laboratory data.

Technology, Incorporated in Dayton, Ohio [49588] applied information from the TSP to an image enhancement project it conducted for Goddard. The project produced both a theoretical and a hardware model for "desmearing" the motion-degraded

pictures from Earth Resources Technology Satellites [ERTS], which will soon be launched. Information from the TSP was used in converting the theoretical model to operational equipment that can eliminate motion-caused blurs in pictures.

A research associate in psychology at Loyola University in Chicago, Illinois [59960] used practical information about Fourier transforms from the TSP in designing experimental equipment for an NSF-funded project in psychophysiology. The equipment is being used to investigate human visual perception. More than 50 hours of research time were saved by using the TSP.

Control Numbers

Tech Brief Number: 68-10069
NASA Center: Goddard Space Flight Center
PATT Case Numbers: 17080, 21368, 35410, 49588, 59960
TEF Number: 24
Date of Latest Information Used: March 30, 1972

PERT VERTICAL CHART DISPLAY

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Rapid review of PERT computer printouts is commonly handicapped by the nongraphic format of the information. The problem can be lessened by using a new format developed at the Aerojet-General Corporation, under contract to the Space Nuclear Systems Office [formerly the Space Nuclear Propulsion Office]. The method, called PERTREE and described in Tech Brief 67-10568, displays essential status elements of a PERT system in a highly graphic, vertical flow display. By orienting the summarized network in a vertical display, it is possible to combine the benefits of "waterfall" schedule sequences with the PERT-generated status data.

The director of systems and data processing for the Wisconsin Tuberculosis and Respiratory Disease Association is adapting PERTREE [and PERT] to develop a systems approach to public health problems [35868]. This approach is necessary to process the enormous amount of data which must be organized to attain sequencing of report production, experiments, and other management tasks relevant to solving a complex problem. Other Wisconsin public health agencies and the National Tuberculosis and Respiratory Disease Association are actively interested in his work, which is currently in the stage of experimentation with adapted computer methods and display techniques. The system will be implemented when this adaptation work has been completed.

Control Numbers

Tech Brief Number: 67-10568
AEC/NASA Center: Space Nuclear Systems Office
PATT Case Number: 35868
TEF Number: 370
Date of Latest Information Used: December 22, 1971

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PHOTOTRANSISTOR MOSAIC

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Beginning in 1962, Westinghouse Electric Corporation executed a contract with NASA's Marshall Space Flight Center [MSFC] that culminated in a miniaturized, solid state television camera in which a phototransistor mosaic replaced the vidicon tube as the imaging device. The camera was designed to withstand severe missile firing shock and to minimize size, weight and power requirements. The fragile vidicon tube was eliminated in favor of a mosaic sensor consisting of 2,500 phototransistors for light sensing and image conversion. A digital readout system sequentially scans the phototransistors at 60 frames per second, producing pictures composed of a series of dots rather than lines. NASA announced the invention in a 1966 Tech Brief and obtained a patent in 1969.

Westinghouse has continued its work in the field, including further contract activities for NASA. A 200,000-element array was scheduled for delivery to MSFC in February 1972. Nonaerospace applications are being initiated, including use of mosaic arrays for nuclear blast monitoring. In one such use, an underground test was monitored with a cost savings of $200,000 largely achieved by eliminating post-blast excavation to retrieve the data record.

Another application is being developed by Westinghouse in cooperation with scientists at the Smith-Kettlewell Institute of Visual Sciences, University of the Pacific, San Francisco, California [76501]. Eight years ago, Dr. C. C. Collins of the Institute began to experiment with tactile image conversion as a means of restoring visual functions in blind subjects. Dr. Collins' early experimental apparatus used a vidicon camera tube and an orthogonal, logical switching matrix to connect, in sequence, the elements of the vidicon image to corresponding elements of a polarized, solenoid stimulator matrix with small Teflon mechanical stimulators in contact with the skin. The system converted the TV image to a two-dimensional facsimile, which was impressed on the skin by mechanical vibration. Evolution of the research resulted in the design of an electrical stimulus array for impressing the converted image on a patch of abdominal skin and replacing the vidicon camera with a phototransistor array. This system is portable and allows considerable mobility for the blind user. In approximately ten hours, the user can learn to recognize familiar objects, dis-

criminate among individuals, and describe their posture, movements and characteristics.

Dr. Collins first learned of the Westinghouse mosaic in 1971 and, subsequently, acquired several of the units. At present, a 20 x 20 phototransistor array is used; however, experiments with a 1,000-element array are to begin soon. A 4,000-element array also is being developed for the project by Westinghouse. Dr. Collins foresees achievement of an operational system in about three years, with expectations that the 4,000-element array will establish the desired level of resolution.

Control Numbers

Tech Brief Number: 66-10112
NASA Center: Marshall Space Flight Center
PATT Case Number: 76501
TEF Number: 104
Date of Latest Information Used: February 1, 1972

SINGLE GUN COLOR CRT

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A current-sensitive, single gun color cathode ray tube, capable of producing a limited range of colors in a monochromatic black and white closed circuit TV system, was developed by two NASA employees at the Electronics Research Center. Differential color is obtained by varying the current in the electron beam; variation in brightness for a given color is achieved by controlling the duty cycle of the electron beam. The uncomplicated apparatus uses a two primary and single gun system in place of the common three primary and three gun color system, resulting in a reduction of the number of video amplifiers and deflection circuits required to display a color TV picture. The picture tube is less complex, utilizing special phosphors characterized by nonlinearity of response to electron beam excitation to achieve color gradations.

The Magnavox Company in Silver Spring, Maryland [57800] is expanding its operations into cable TV systems. A senior staff engineer requested funds to study biomedical applications of cable TV and collected literature relevant to such a study, including TSP 70-10464 describing the new NASA color system. The development was shifted to another group in the company which plans to use flat panel plasma displays. There are no current plans to use the single gun technology.

Singer-Librascope in Glendale, California [58036] is developing new display systems for the Navy. A laboratory model of he NASA single gun color system will be constructed, and the final outcome of efforts to use the technology should be known by October 1973.

CBS Laboratories in Stamford, Connecticut [58896] is evaluating the invention for adaptation to color movie-making for television. The firm's intention is to develop a high resolution color image on videotape, which can be edited electronically and recorded for storage using laser beams. The process would bypass the photographic film stage and achieve considerable cost savings, as compared with the currently used, three gun color system for television.

GTE Sylvania, Incorporated in Needham Heights, Massachusetts [57882] built an experimental prototype of the driver circuitry and single gun color CRT in order to evaluate its potential for inclusion in a commercial product under development. While the circuitry fit well electronically, the color shift capability of the system was not adequate for the company's purposes. The approach was subsequently abandoned.

Control Numbers

Tech Brief Number: 70-10464
NASA Center: Electronics Research Center
PATT Case Numbers: 57800, 57882, 58036, 58896
TEF Number: 393
Date of Latest Information Used: October 11, 1972

SURFACE TEMPERATURE MAPPING WITH IR PHOTO PYROMETRY

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

An advanced procedure for measuring and mapping the distribution of temperatures on a heated surface is now available as a result of studies performed at NASA's Lewis Research Center. The method utilizes commercially available equipment to collect, detect, and measure a narrow bandwidth of emitted infrared radiation and convert the data to a topographic style map of the surface. Major components of the system are the heated surface to be measured, which has a reference thermocouple attached; an optical viewpath and camera for recording thermal radiation on IR-sensitive film; a closely controlled film developing unit; a densitometer for measuring and recording the densities of the photographic images and plotting isodensity contours; and a method for converting image densities to temperatures.

The IR photographic pyrometry method is superior to conventional surface thermocouple arrays or radiation pyrometers in several respects. Higher accuracy, a greater range of temperature measurement, and simplification of data handling are achieved. In addition, a thermal photograph can be taken in one second or less, providing a permanent record; complete temperature distribution data can be obtained without physically contacting or interfering with the heated surface except for the reference thermocouple.

Dr. K. T. Feldman of the University of New Mexico in Albuquerque [42606] intends to use the procedure for a basic research project concerning heated surface temperature distributions, some of which are evaporating water surfaces. The temperatures involved are under 500° F. Although IR detection is more commonly used at higher temperatures, Dr. Feldman is certain that the method will be appropriate for his research. He has submitted a request for an $8,000 item of Department of Defense surplus equipment with which to set up the IR photographic pyrometry method.

Control Numbers

Tech Brief Number: 69-10113
NASA Center: Lewis Research Center
PATT Case Number: 42606
TEF Number: 371
Date of Latest Information Used: March 30, 1972

THE GENERAL ELECTRIC COMPUTED COLOR TV DISPLAY

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

General Electric Company, under contracts with NASA Manned Spacecraft Center, has conducted extensive development work on a computed color TV display system for simulation of spacecraft docking maneuvers, space shuttle landing, and other space-related applications [64101]. The work began in the late 1950's under funding from the Office of Naval Research; it then continued under NASA funding and internal financing at G.E. Used primarily by NASA to date, the scene generator develops simulation displays without using a physical model. A basic scene is created as a computer program; inputs from the operator's control stick and a few dials, such as speed control, produce calculations which then alter the display to reflect the new perspective and position of the operator relative to the basic scene. The calculated view is then presented in real time on a color TV screen by raster scanning. The visual display consists of a textured plane surface, blue sky [if appropriate], point sources of light and various objects. The objects are composed from colored planar segments outlined by straight line segments.

The original unit developed for MSC contained three TV screens for different views of the same scene and the capability to produce up to 240 edges for objects. A more advanced unit, delivered to MSC in October 1971, provides 750 edges [about 200 planar segments] for greater detail and other display improvements resulting from NASA-supported hardware developments. Scenes with up to twenty times greater detail have been made for NASA by generating the scene on TV in slow time, filming the scene with a movie camera, and showing the film at a faster speed.

General Electric, using internal funds, developed the software for several potential applications: highway planning for the New York Highway Department; control tower operator training for the Federal Aviation Administration; aircraft simulators for military and commercial pilot training; ocean and ship simulation for training supertanker captains; and other areas such as animation for TV advertising. Anticipating different uses for any unit purchased, G.E. also has available fast storage equipment [tape or disc file] so that a program for one scene can be replaced rapidly with a program

for a different scene. The basic scene generator is now designed in modular form so that fairly standard components may be used to assemble units with various capabilities. Prices range from $250,000 to $1,500,000. A significant market for the units does not exist at the present time; however, G.E. anticipates substantial sales in the future.

Professor Peter Kamnitzer, Head of the School of Architecture and Urban Planning at U.C.L.A., has developed a cityscape program for urban planning with assistance from G.E. and MSC personnel [64102]. Kamnitzer used the scene generator to produce and film a TV cityscape image to simulate various drives through the streets, along with different visual perspectives. He has shown the film at urban planning conferences in the U.S. and Europe. With funding from the Bureau of Highway Safety in the U.S. Department of Transportation, Kamnitzer and a fellow colleague are exploring some applications of the scene generator for highway safety planning. Kamnitzer is presently seeking funds to establish an Urban Simulation Laboratory at U.C.L.A., which would assemble known types of urban models, perform simulations with the models, and develop planning techniques and actual plans from the simulations. If funded, the laboratory is expected to create considerable interest among architects and city planners.

Control Numbers

Tech Brief Number: None
NASA Center: Manned Spacecraft Center
PATT Case Numbers: 64101, 64102
TEF Number: 389
Date of Latest Information Used: October 4, 1971

UNIVERSAL CONTROL AND DISPLAY CONSOLE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

In July 1970, General Electric Company's Houston Space Division executed a contract with Manned Spacecraft Center to define, design, and build the prototype of a Universal Control and Display Console [UCDC] for NASA's Unified Test Equipment [UTE] checkout system [63801]. As part of the contractual obligations, G. E. analyzed checkout requirements for a space shuttle and space station, conducted engineering tradeoff studies to determine optimum equipment specifications and configurations, designed and implemented the hardware and software components for the UCDC, tested the system, and provided for its integration with other existing portions of the UTE system. A prototype was developed and delivered to NASA in July 1971.

As part of the tradeoff studies, G. E. ascertained that costs were minimized by using universal, rather than specialized, test equipment and modular construction. Modular universal equipment will decrease equipment inventory and improve manpower utilization, especially if the test equipment is automated to reduce time requirements for preparing and conducting tests. The prototype also promotes efficiency by relying on hardware components as much as possible for performing repetitive functions. The controller serves both as a display processor and as a data acquisition and command processor. Operator interface consists of a variable function plasma display, keyboard entry, and two color CRT's to display special symbols, trend lines, bar graphs, and other application-oriented visual information; tutorial decision trees to guide the operator; and similar images which color code crucial information for rapid comprehension.

The UCDC at MSC thus provides data processing and control to: initiate command signals to the equipment system, select and display parameters of the system status and operating characteristics, perform automatic closed-loop operations, and permit test equipment or monitoring modifications by the operator.

G. E. has published and distributed an advertising brochure for the system, which the company has designated IDAC 560A [Information Display and Control system]. The company is adapting the symbology, software, and modular configurations for potential

applications in centralized monitoring and control of mass transit systems, oil field production, electric power generation and distribution, shipboard systems, and other complex industrial equipment systems. The basic unit is priced on the order of magnitude of $100,000. The system offers great potential for reducing operating costs and increasing efficiency; it may become the standard for the next generation of centralized monitoring and control systems.

Control Numbers

Tech Brief Number:	None
NASA Center:	Manned Spacecraft Center
PATT Case Number:	63801
TEF Number:	388
Date of Latest Information Used:	October 17, 1972

VIDEOFILE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

Ampex Corporation is now commercializing a new computerized record-keeping system that was partially developed under contract to NASA's Marshall Space Flight Center [66201]. The original system was a unique one, incorporating the first application of professional broadcast video technology, in conjunction with a new tape transport mechanism and a digital address system to direct computer indexing and tape handling. Control interfaces were handled by a small SEL computer. After completing the NASA contract, Ampex continued to develop the system primarily to improve picture resolution. In its present configuration, the system's display unit is a 1280-line vidicon tube [an improvement over the 1050-line display for NASA], a new camera for use with the vidicon tube, and an electrostatic hard copy printer. These equipment developments were accomplished in-house by Ampex.

A new division, Videofile Information Systems Division, was subsequently created by Ampex to produce and market the information system. Sales to date have exceeded $18 million. Purchasers of the system have been the Los Angeles Sheriff's Department, the Royal Canadian Mounted Police, the Illinois Department of Enforcement, Southern Pacific Railroad, Federal Housing Administration, Kings County Hospital [Brooklyn], and two insurance companies.

Ampex anticipates the system will have a major impact in law enforcement record-keeping, retrieval and display. The firm is presently negotiating with twelve law enforcement agencies, of which three are ready to purchase the system. The Los Angeles Sheriff's Department [largest sale to date] estimated that the system would save the office $1.5 million annually in record-keeping costs and reduce file space by 90 percent. The system will store fingerprints, photographs, and complete dossiers and make the information available for viewing on consoles at any of the fifteen county substations.

Control Numbers

Tech Brief Number: None
NASA Center: Marshall Space Flight Center
PATT Case Number: 66201
TEF Number: 226
Date of Latest Information Used: October 6, 1971

VIS-A-PLAN MANAGEMENT TECHNIQUE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

One of the best known aerospace management procedures is the Program Evaluation and Review Technique [PERT]. The usefulness of PERT, however, has been limited to the management of very large enterprises. Trans World Airlines management specialist, Nathan Ranck, under contract to NASA, developed a visual display technique which reduced the complexities of PERT analyses. The technique, known as Vis-a-Plan [VISualize-a-PLAN], was used for scheduling ground support activities at Cape Kennedy. Vis-a-Plan combines the logic sequence of PERT with the time-scale method developed by Gantt; it also adds a few new features to portray an entire project rectilinearly on a time base. Each sub-task is shown, described, and integrated into the total work effort.

The Vis-a-Plan method was first described by Ranck in a paper copyrighted in 1966, and, in the following year, he prepared Tech Brief 67-10240, entitled "Vis-a-Plan Management Technique." The Tech Brief was subsequently described in several trade publications, including Ceramic Age, and a full article authored by Ranck appeared in the Journal of Industrial Engineering.

More than 77 organizations have requested copies of the Vis-a-Plan TSP. Requests came from managers, scientists, engineers, and others working for organizations of various sizes and in many industries.

The Scott Division of A-T-O, Incorporated, a manufacturer of aviation, fire, and safety equipment in Lancaster, New York [5054], adopted the method in 1968 and is still using it. The firm had been experiencing cost and time overruns and studied several project control methods. Vis-a-Plan fit the firm's needs and was implemented immediately on a few special projects. Within six months, all R&D engineering projects were controlled with the method; its routine use now requires only the services of a posting clerk. At least a ten percent cost reduction on each project saves the firm more than $200,000 annually.

Late in 1967, Owens-Illinois Corporation in Toledo, Ohio [5067] applied Vis-a-Plan to several small R&D projects for which PERT was ineffective. Initially, there was some opposition as the

display made some deficient performances obvious; however, it is now appreciated by all concerned. One man spends about a third of his time routinely updating the charts.

Smith and Loveless, a division of Union Tank Car Company in Lenexa, Kansas [23570], which manufactures sewage treatment equipment, evaluated the TSP during an effort to improve inventory and production control systems. Management consultants hired to assist in the project later convinced the firm's officers that a modified Gantt Chart and Critical Path Method approach would be better suited to the problem.

The University of Denver School of Engineering [28862] implemented the method to coordinate part of a multidisciplinary program involving students, faculty and research engineers. The program required patent evaluation, prototype development, market research, and introduction of an energy-absorbing device based on NASA patents. During initial stages, the unique nature of the project and the diverse backgrounds of the participants required a good means of project control; Vis-a-Plan was successfully used, but is no longer needed.

Control Numbers

Tech Brief Number: 67-10240
NASA Center: Kennedy Spacecraft Center
PATT Case Numbers: 5054, 5067, 23570, 28862
TEF Number: 28
Date of Latest Information Used: March 15, 1972

VISUAL DISPLAY PANEL AND COMPUTER INPUT/OUTPUT DEVICE

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

A graphic visual display panel that functions as a computer input/output device was developed at NASA's Electronics Research Center. The panel permits data entry and erasure with a probe; it has an inherent memory for use on time-shared systems; and the data can be scrutinized for error prior to entry into a computer. The display matrix consists of many gas-filled cavities inside a transparent glass case. The gas elements are maintained at a sustaining voltage, and data are entered by supplying additional voltage which illuminates selected matrix elements by ionization. An external probe [or internal electrode] fires any selected element, which remains fired until a phase reversal of the probe current causes erasure by reducing voltage in the element below the sustaining voltage. This characteristic provides an inherent memory for information storage. The device has been described by NASA in Tech Brief 70-10476.

A Southwestern manufacturing firm [55508] responded to a Federal Aviation Administration [FAA] request for price quotations for improved weather information display systems. The FAA has been using a teletype operation and wanted a new, multiple display, television system to provide instantaneous updating and transmission of weather data from a central weather station. The firm demonstrated a model of a system that incorporated the NASA plasma display, but did not win the bidding. The model is being demonstrated to other potential clients, and development work is continuing.

Cinecraft, Incorporated in Cleveland, Ohio [57912] is evaluating the display for possible use as a simple counting device. The company produces industrial motion pictures and uses many small mechanical devices for such things as counting frames, notches and footage. The reliability and versatility of these devices is unsatisfactory, so the plasma display is being evaluated as a substitute and improvement. The NASA panel is also being investigated as a potential input device for computer animation.

Burroughs Corporation in McLean, Virginia [58894] sells a plasma display unit similar to that described in the TSP. A Burroughs' product manager reviewed the TSP to compare the NASA

device with his product, and found no differences significant enough to warrant any expensive modifications.

Control Numbers

Tech Brief Number:	70-10476
NASA Center:	Electronics Research Center
PATT Case Numbers:	55508, 57912, 58894
TEF Number:	397
Date of Latest Information Used:	November 3, 1971

WEATHER SATELLITE IMAGE DISPLAY

TECHNOLOGY TRANSFER EXAMPLE SUMMARY

The Automatic Picture Transmission [APT] system developed by NASA's Goddard Space Flight Center is a unique television system that enables a weather satellite to take cloudcover pictures and automatically transmit them to simple, inexpensive ground stations as the satellite passes overhead. The APT system has been operational in the Nimbus and ESSA satellites for approximately six years.

The ground station display unit, also developed at Goddard, is an integral part of the APT system which provides both television and photographic outputs. The basic APT receiver consists of a rotatable antenna, preamplifier, FM receiver, video electronics package, oscilloscope display device, and a scope camera mounted on the oscilloscope to give a permanent display. A video tape recorder and a direct readout infrared radiometer [DRIR] conversion unit are optional parts of the receiver. The DRIR unit permits the same receiver equipment to display the satellite's infrared imagery.

NASA has published two documents that give detailed instructions for building an APT receiver: "Constructing Inexpensive Automatic Picture-Transmission Ground Stations" [SP-5079] in 1968, and "Weather Satellite Picture Receiving Stations" [SP-5080] in 1969. The second publication also provides a detailed description of the receiver's operation. Using these plans, anyone with a basic knowledge of electronics could make his own receiver with parts costing under $500. An estimated 350 of these units have been or are being built for private, government, and research use around the world.

EMR Division of Weston Instruments, Incorporated in College Park, Maryland [431] produced the Goddard-designed receivers for NASA and has since found a commercial market for a new product line based on the NASA design. The company has sold approximately fifty units ranging in price from $7,000 to $14,000. The following illustrations, involving two of the EMR units, point out the fact that the primary function of the unit is in the context of a broader visual information communication network.

The National Marine Fisheries Service, an agency of the U. S. Department of Commerce located in La Jolla, California

[78002], integrates the APT output with other information sources to produce two charts showing seastate and atmospheric information for the Pacific tuna fleet. The APT receiver provides approximately 25 percent of the input to the charts. This fishery/advisory information is transmitted regularly to the fleet via a radio facsimile [FAX] broadcast from La Jolla. FAX equipment has now been installed onboard forty modern tuna boats in the fleet, and more installations are planned. By using these charts, tuna fisherman have reduced the time spent searching for tuna and the variability of catch.

The National Environmental Satellite Service [NESS], part of the U. S. Department of Commerce in Washington, D. C. [78001], disseminates the imagery from its APT receiver through several networks. One involves a FAX circuit transmission to 30 of the National Weather Service stations. Another network supplies the APT video tapes to commercial wire services, which then transmit wirephotos to local newspapers and television stations. The remaining 15 Weather Service stations have their own individual APT receivers.

In addition to EMR, two other companies in the United States produce similar units. Approximately 150 commercial units are now in operation in more than 50 different countries. Most of these ground stations are operated by government agencies. NESS, as the coordinating agency, has received numerous letters from abroad stating the profound impact of the weather satellite information provided by the units: sea ice information for shipping, fishing, and ice-breaking operations in Canada, Iceland, Sweden, Argentina and other countries; weather conditions which are favorable to breeding or concentration of locusts in eastern Africa; and weather forecasting in every country. The acquisition and use of APT receivers, as well as the development of related dissemination networks, indicates an expanding world-wide utilization of the weather satellite imagery and the ground display unit designed at Goddard.

Control Numbers

Tech Brief Number: None
NASA Center: Goddard Space Flight Center
PATT Case Numbers: 431, 78001, 78002
TEF Numbers: 26, 194
Date of Latest Information Used: March 20, 1972