



RANN UTILIZATION EXPERIENCE

**REPORT TO
THE NATIONAL SCIENCE FOUNDATION
Case Studies 32 through 41**

Washington, D.C.

November 1976

Compiled by:

R. M. Burger
M. F. Massoglia

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

As a Final Report on:
Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

BIBLIOGRAPHIC DATA SHEET	1. Report No. NSF/RA-760413	2.	3. Recipient's Accession No.
4. Title and Subtitle RANN Utilization Experience (Case Studies 32 through 41)		5. Report Date November 1976	
		6.	
7. Author(s) R.M. Burger, M.F. Massoglia		8. Performing Organization Rept. No.	
9. Performing Organization Name and Address Research Triangle Institute P.O. Box 12194 Research Triangle Park, NC 27709		10. Project/Task/Work Unit No.	
		11. Contract/Grant No. C7617165	
12. Sponsoring Organization Name and Address Research Applied to National Needs (RANN) National Science Foundation Washington, D.C. 20550		13. Type of Report & Period Covered Final Report	
		14.	
15. Supplementary Notes Case Studies 1 - 41 are available from NTIS			
16. Abstracts This report contains case studies of the utilization of research results of ten Research Applied to National Needs (RANN) projects that were selected as being both broadly representative of the RANN program and of some interest and significance relative to national needs. The selection procedures were informal and were carried out interactively within NSF/RANN management. These case studies follow thirty-one that were previously prepared and distributed and will be followed by additional utilization case studies. Findings and analysis are confined to the individual cases. Subject areas include: (1) Creating and evaluating an experimental industry-university furniture R&D applications institute; (2) Innovation centers; (3) The less cash/less check society: an in-depth technology assessment; (4) Urban technology system; (5) Energy absorption characteristics of structural systems subjected to earthquake excitation; (6) Metromex; (7) The Texas Energy Advisory Council; (8) Tertiary oil recovery; (9) Assessment of a new textile technology; and (10) Automated bending system for the fabrication of ship frames.			
17. Key Words and Document Analysis. 17a. Descriptors <div style="display: flex; justify-content: space-between;"> <div> Research Research Management Research Projects Industry Universities Finance Shipbuilding Earthquake Resistant Structures </div> <div> Textiles Oil Recovery </div> </div>			
17b. Identifiers/Open-Ended Terms <div style="display: flex; justify-content: space-between;"> <div> Case Studies Findings Technology Assessment Urban Technology Research Applied to National Needs (RANN) Metromex </div> <div> Texas Energy Advisory Council Technology Utilization Research Utilization </div> </div>			
17c. COSATI Field/Group			
18. Availability Statement NTIS		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 328
		20. Security Class (This Page) UNCLASSIFIED	22. Price





RANN UTILIZATION EXPERIENCE

**REPORT TO
THE NATIONAL SCIENCE FOUNDATION
Case Studies 32 through 41**

Washington, D.C.

November 1976

1-a

SUMMARY

This report contains case studies of the utilization of research results of ten Research Applied to National Needs (RANN) projects that were selected as being both broadly representative of the RANN program and of some interest and significance relative to national needs. The selection procedures were informal, and were carried out interactively within NSF/RANN management.

These case studies follow thirty-one that were previously prepared and distributed, and will be followed by additional utilization case studies. Findings and analysis are confined to the individual cases. No general findings are given in this report.

Table of Contents

	<u>PAGE NO.</u>
SUMMARY	i
INTRODUCTION	1
CASE 32 CREATING AND EVALUATING AN EXPERIMENTAL INDUSTRY-UNIVERSITY FURNITURE R&D APPLICATIONS INSTITUTE	32-1
CASE 33 INNOVATION CENTERS	33-1
CASE 34 THE LESS CASH/LESS CHECK SOCIETY: AN IN-DEPTH TECHNOLOGY ASSESSMENT	34-1
CASE 35 URBAN TECHNOLOGY SYSTEM	35-1
CASE 36 ENERGY ABSORPTION CHARACTERISTICS OF STRUCTURAL SYSTEMS SUBJECTED TO EARTHQUAKE EXCITATION	36-1
CASE 37 METROMEX	37-1
CASE 38 THE TEXAS ENERGY ADVISORY COUNCIL	38-1
CASE 39 TERTIARY OIL RECOVERY	39-1
CASE 40 ASSESSMENT OF A NEW TEXTILE TECHNOLOGY	40-1
CASE 41 AUTOMATED BENDING SYSTEM FOR THE FABRICATION OF SHIP FRAMES (Update of Case Study No. 5)	41-1

Any opinions, findings, conclusions
or recommendations expressed in this
publication are those of the author(s)
and do not necessarily reflect the views
of the National Science Foundation.

INTRODUCTION

Background

The Research Applied to National Needs (RANN) Program of the National Science Foundation supports research on selected problems of national importance with the objective of contributing to their practical, timely solution. Various studies have been undertaken to assess the prompt utilization of RANN research. One utilization assessment tool is the case study wherein an individual project is examined, its utilization determined, the various factors that apparently affect its utilization are identified, and conclusions are derived relative to its utilization experience.

Research Triangle Institute (RTI) completed an initial group of twenty-one such case studies in 1975.* The projects selected for those case studies were among the better utilized ones as judged by RANN management. In that effort, and in subsequent analyses by NSF/RANN, much has been learned on how to conduct case studies so as to improve their effectiveness both in communicating the experience of the project and in revealing the features of the utilization process in general. This collective experience has been applied, albeit not with complete success, in the preparation of these new case studies.

Ten additional case studies were issued in September 1976** for projects that were indicated as being well utilized. In this report, ten new case studies are presented. Essential information on these is given in Table 1. Additional case studies are being prepared and will be presented in later reports.

*R.M. Burger, RANN Utilization Experience Final Report to the National Science Foundation, Research Triangle Institute, June 16, 1975.

**R.M. Burger and M.F. Massoglia, RANN Utilization Experience, Report to the National Science Foundation, Case Studies 22 through 31, Research Triangle Institute, August 31, 1976.

TABLE 1. RANN PROJECTS FOR WHICH CASE STUDIES ARE INCLUDED IN THIS REPORT

PROJECT	PRINCIPAL INVESTIGATOR(S)	NSF PROGRAM MANAGER	TERM	FUNDING
32 Creating and Evaluating an Experimental Industry-University Furniture R&D Applications Institute	John Markle Furniture R&D Applications Institute (Succeeded by Hugh Burton)	Robert Colton	7/73-9/78	\$ 708,700
33 Innovation Centers	Gerald G. Udell, University of Oregon Yao Tzu Li, Massachusetts Institute of Technology Dwight M. Baumann, Carnegie-Mellon University	Robert Colton	7/73-9/78	\$2,993,650
34 The Less Cash/Less Check Society--An In-Depth Technology Assessment	Martin L. Ernst A.D. Little, Inc.	Joseph Coates G. Patrick Johnson	9/73-6/75	\$ 221,966
35 Urban Technology System	Ronald J. Philips Public Technology, Inc.	Evan Anderson Elisha C. Freedman Thomas P. Anderson	7/73-11/77	\$4,355,930
36 Energy Absorption Characteristics of Structural Systems Subjected to Earthquake Excitation	Ray W. Clough Earthquake Engineering Research Center, University of California at Berkeley	John B. Scalzi	11/74-4/76	\$ 944,500
37 METROMEX	S. Changnon, Illinois State Water Survey R. Braham, University of Chicago A. Auer, University of Wyoming E. Uthe, Stanford Research Institute	C. Downie	71-76	\$2,980,000

TABLE 1. (CONTINUED)

PROJECT	PRINCIPAL INVESTIGATOR(S)	NSF PROGRAM MANAGER	TERM	FUNDING
38 The Texas Energy Advisory Council Research Project	Edward Azar University of North Carolina at Chapel Hill	Bruce Smith	5/74- 5/75	\$ 534,000
39 Tertiary Oil Recovery	William H. Wade Robert S. Schechter University of Texas at Austin	Donald Senich	4/74- 10/77	\$ 349,900
40 Assessment of a New Textile Technology	William K. Walsh North Carolina State University	J.C. Aller	4/74- 4/77	\$ 300,000
41 Automated Bending System for the Fabrication of Ship Frames (Update of Case Study No. 5)	Harry W. Mergler Case Western Reserve University	Bernard Chern	8/72- 7/76	\$ 279,000

An important application of the case studies is their usefulness for comparative analyses. To facilitate this, a degree of necessary uniformity is imposed. However, it must be emphasized that a case study is not constrained to a limited set of questions and answers. Flexibility in the pursuit of information is both desirable and necessary to obtain a valid measure of utilization. The Case Investigator must probe with zeal into the various nooks and crannies of the conceptualization-research-dissemination-utilization process in order to obtain an accurate and complete study.

What constitutes utilization of research results is a difficult question to answer. Measures of utilization that are operationally useful and are broadly applicable have eluded us so far. In the interim, we postulate that for RANN, utilization implies a contribution toward meeting a need of national importance. The research contributions might range from a minor influence to directly attributable important changes, actions, or decisions. In a case study, some or all of the research utilizations are identified; however, when utilization is widespread, the less important categories can only be sampled. The extent of this sampling is determined by the case investigator on the basis of the results obtained and the effort available. Since utilization is frequently either feast or famine, this restriction is less severe than would appear.

These case studies were prepared under Contract NSF-C76-17165 with Research Triangle Institute. The project began on April 1, 1976, and is continuing.

Dr. Robert Burger is Principal Investigator for this study. Dr. Martin Massoglia is a Co-investigator and is administering the effort. These individuals were joined by 7 other professionals at RTI in performing these case studies. This project team is identified in Table 2. The level of effort is such that, on the average, about 2.5 man-weeks are available to prepare each of the

TABLE 2. PROJECT PARTICIPANTS

	PROJECT	CASE INVESTIGATOR	TECHNICAL REVIEWER
32	Creating and Evaluating an Experimental Industry-University Furniture R&D Applications Institute	M.F. Massoglia	G.M. Armstrong (UNC)
33	Innovation Centers	R.M. Burger	J. Kohl (NCSU)
34	The Less Cash/Less Check Society--An In-Depth Technology Assessment	J.N. Brown	W.P. Yohe (Duke)
35	Urban Technology System	J.N. Brown	O. White (UNC)
36	Energy Absorption Characteristics of Structural Systems Subjected to Earthquake Excitation	D.F. Tolman	J.C. Smith (NCSU)
37	METROMEX	F.M. Vukovich	E. Droessler (NCSU)
38	The Texas Energy Advisory Council Research Project	P.S. McMullan	E. Azar (UNC)
39	Tertiary Oil Recovery	M. v.E. Rulison	D.O. Shah (Univ. of Fla.)
40	Assessment of a New Textile Technology	R. Whisnant	D. Turner (UNC)
41	Automated Bending System for the Fabrication of Ship Frames (Update of Case Study No. 5)	R. Donovan	D. Wright (Duke)

case studies. This necessitates heavy reliance on information supplied by NSF/RANN program managers and on project principal investigators. The procedures employed are described in a following section of this report.

Dr. Samuel J. Raff of the NSF Division of Exploratory Research and Systems Analysis is Program Manager for this effort. He coordinated the project selection, assisted in arranging the many required liaisons with NSF staff, and has reviewed each of these case studies. This participation has had an important influence on the accuracy and completeness of the information provided in this report.

Project Selection

NSF made the selection of projects studied here. The procedures involved in this selection were informal and involved communications with the program managers, a preliminary selection at the division level, and final selection at the level of the Research Applications Directorate. Because of the informality of the procedures, the selection criteria were not formally defined, but the general intention was that the group of projects be broadly representative of the types of work being done in the RANN program, and that individual projects be of interest and of some probable ultimate significance to national needs.

Procedures

The objective of a case study is to identify and describe the specific utilization of the project in an accurate and comprehensive manner. In meeting this objective, it is necessary to also discuss, to some extent, the nature of the research and the project itself. The Case Investigator, assigned from RTI's staff, obtains all relevant information on the project and prepares the case study.

Every case has a Technical Reviewer. He provides the Case Investigator with additional specialized background knowledge, should that be required. The Technical Reviewer also reviews the case study for technical accuracy and independently derives conclusions on the utilization factors relevant to the project. The Case Investigators and Technical Reviewers for the ten case studies included in this report are identified in Table 2.

The procedures employed in carrying out these utilization case studies were dominated by the schedule. Programmatic requirements of NSF necessitated rapid accomplishment. This in turn required close cooperation with and support from NSF. The procedures employed were as follows:

- Projects for which case studies were to be prepared were selected by the RANN Program Manager, Dr. Raff, in consultation with RANN management, as described in the previous subsection.
- Assignments of case investigators and technical reviewers were made to the individual cases as shown in Table 2, and interviews of NSF program managers were scheduled. In these interviews, the case investigators discussed the cases and asked questions as necessary to acquire information. In each case, the program manager was asked to inform the principal investigator of the project that the utilization study was being made.
- Case investigators provided technical reviewers with information on the case study, discussed with them the perspective of the research, and obtained guidance for the user interviews.

- Each case investigator subsequently contacted the project principal investigator to discuss the utilization study. In each case, first contact was by telephone. In a majority of the case studies, this was followed by a visit to the principal investigators for more intensive discussions. Cooperation of the principal investigators was very good.
- The identified users were contacted, primarily by telephone, but written communications and visits were also employed. Each was requested to provide an evaluation of the project as related to his needs and to relate the uses he had found for the research results.
- Each of the case investigators prepared a case study report, in most cases with the direct participation of the Technical Reviewer. The ten completed reports were reviewed by the Technical Reviewer and subsequently submitted to NSF and to the ten principal investigators for review.
- Burger, Massoglia, Raff, and, when necessary, the Case Investigator discussed the comments obtained from the reviewers. The case investigators prepared the final case studies, which are included in this report.



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 32

**CREATING AND EVALUATING AN EXPERIMENTAL
INDUSTRY—UNIVERSITY FURNITURE R&D APPLICATIONS
INSTITUTE**

NORTH CAROLINA STATE UNIVERSITY

Case Investigator:

M. F. Massoglia

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

G. M. Armstrong

Graduate School of Business
University of North Carolina
Chapel Hill, North Carolina 27514

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

CREATING AND EVALUATING AN EXPERIMENTAL INDUSTRY—UNIVERSITY FURNITURE R&D APPLICATIONS INSTITUTE

Introduction and Summary

This case study investigates one phase of a three-part experiment designed to explore the feasibility of linking university R&D capabilities and resources with industry's needs in order to move technology more quickly into the marketplace. The experiment is part of the overall National Science Foundation Research Applied to National Needs (NSF/RANN) Experimental Research and Development Incentives Program (RDI), and is designed to determine if initial Federal funding of cooperative industry/university R&D programs will stimulate continued funding by industry. The primary hypothesis is that the rate of technological innovation in industries that do not maintain active and viable R&D programs can be increased by a realignment of the institutional relationships between universities and business firms. Three projects comprise this experiment:

- North Carolina State University/Furniture Industry,
- Massachusetts Institute of Technology/Polymer Processing Industry, and
- MITRE Corporation/New England Utilities.

This case study reports on the North Carolina State University/Furniture Industry project.

In recent years, the furniture industry, like other traditional and craft-oriented industries, has experienced a decline in revenues. A contributory factor has been the reluctance and resistance of the furniture industry to invest in research and development aimed at reducing manufacturing costs while maintaining or improving product quality. The fragmented nature of the industry--a large

number of relatively small firms--and the institutional barriers to innovation resulting from the traditional market orientation of the industry, are the major reasons for the extremely limited R&D investment.

To overcome the traditional barriers to innovation and to demonstrate the merit of joint university/industry research, North Carolina State University and six sponsoring furniture firms established a Furniture R&D Applications Institute. The Institute carries out joint university/industry programs involving:

- use of substantial Federal dollars for each dollar expended by the furniture industry to magnify the benefits of industry support,
- use of up to 20 percent of the Institute's resources for answering specific industry requests for short-term assistance in problem solving, for specific information, etc., and
- initial work with a relatively small number of furniture-manufacturing firms--initial sponsors--to demonstrate the benefits of a cooperative R&D program.

All indicators point to the successful completion of the program with the Institute being fully funded by the industry at the end of the grant period in 1978. Activity and contacts with the furniture industry have increased with the appointment of a permanent full-time director in August 1975 and liaison personnel. In addition, the results of research conducted by the Institute/industry team have been commercially adopted, including the Clark Chair Frame, improved lumber yield and quality improvement programs, and vacuum wipers. As successes are experienced, the imitative nature of the furniture industry should result in attracting progressively more sponsors.

The fact that the Institute is but one aspect of three projects that were created, designed, and managed by NSF is a unique feature of this case study. This circumstance requires that the Program Manager, Mr. Robert Colton, be an

active participant in all phases of the experiment, and this is the case. NSF has employed a flexible contractual instrument, the cooperation agreement with North Carolina State University, the parent institution. The Program Manager maintains close and continuous liaison with the Furniture R&D Application Institute to assure that the overall experiment remains an entity rather than become a group of projects. The overall results of the RDI experiment, and their utilization, have not yet developed--this will come with time. At this point, utilization is primarily associated with the research products developing from the Furniture R&D Applications Institute.

Research Description

During the past decade, many traditional industries have experienced declining revenues. This trend is the result of the increasing import of products of at least comparable quality that are available at a lower cost to the consumer and, in part, by the reluctance of these industries to invest in research and development designed to reduce manufacturing costs without compromising product quality. For example, the furniture industry spends less than 0.3 percent of its sales revenues for research and development, even though great potential exists for productive innovation in the industry.

In most firms, the process of adopting innovations is generally recognized as being a two-phase process involving (1) initiation phase and (2) implementation. The initiation phase includes problem recognition and awareness, information gathering and evaluation, and the adoption decision. The implementation phase involves communicating the adoption decision and related information to those who must use and accept the innovation. The two phases are often carried out in different echelons of the firm.

Research in the field of innovation has shown that the rate of adoption of innovations within a firm or industry is affected by a number of factors. The size of individual firms and the availability of financial resources and manpower are important in the development and implementation of innovative solutions to the firm's problems. The firm's complexity, e.g., the number of "professionals" it employs, is important in awareness and evaluation of innovations. The centralization of authority in a firm affects its decisions concerning adoption of innovations. Other important factors are demonstrated return on investment, cost, risk, and relative advantage of the innovation over current methods.

In the furniture industry, most of these factors act as barriers to innovation. The furniture industry, comprised of a large number of relatively small firms, is a classic example of a traditionally fragmented industry. In 1971, there were 553 plants in North Carolina employing 63,000 people who produced approximately \$636 million value added by manufacturing. This amounts to approximately \$1.15 million value added per plant. In the same year the furniture industry in North Carolina invested approximately \$28 million in new plants. It becomes evident from even these cursory data that very few firms are of the size and capability to engage in significant R&D efforts.

The industry has relatively low levels of complexity that inhibit the flow of information necessary for the awareness and evaluation of new technology. Because most individual furniture-manufacturing firms are small, craftsman-oriented, and family owned, decisionmaking is highly centralized, which tends to be a barrier to innovation.

The furniture industry's outlook is short-term, and many firms expect investments for improvements to pay for themselves within a year. This typical

narrowness of the industry's planning horizon tends to stifle interest in research projects or in the adoption of new technology for the solutions of old problems. The fragmented nature of the industry and the common practice of individual firms copying styles and methods from each other generate fears that any individually sponsored R&D will result in benefits to the industry as a whole and, thus, not improve the competitive position of the firm actually performing the research.

Finally, the industry has an almost overriding market orientation. Top management's innovative efforts and energies are normally applied to the product/sales aspects of operations, at times to the detriment of design and production techniques.

To overcome the furniture industry's minimal support of R&D and its inherent suspicion of and hostility toward innovation, NCSU proposed to NSF/RANN that a Furniture R&D Applications Institute be established at NCSU under joint university and industry sponsorship. The purpose of the Institute would be to increase the rate of innovation in the furniture industry through jointly funded R&D designed to meet the current needs of the industry. As a result of the grant proposal submitted in 1973 and in furtherance of the RDI program, NSF/RANN funded the project for a five-year period for \$708,700. General information on annual funding levels and other project data are contained in table 32-1. The Institute is currently comprised of NCSU faculty and seven sponsoring firms: Bernhardt Industries,* Burlington House Furniture,* Burris Industries,* Fox Manufacturing Company,* Stanley Furniture Company,* AMSTORE

*These industries were original sponsors. A sixth industry, Athens Home Decor, initially sponsored the Institute, but withdrew sponsorship because of parent organization policy of retrenchment during the 1974-1975 slump experienced by the furniture industry. The Institute reports that Athens Home Decor is considering renewed sponsorship association.

Table 32-1
PROJECT INFORMATION

Project Title Creating and Evaluating an Experimental Industry- University Furniture R&D Applications Institute	Grant/Contract No. CG-0004																					
RANN Program Manager Dr. Robert Colton	RANN Program Area Experimental Research and Development Incentives Program (RDI)																					
Principal Investigator(s) Mr. John Markle Director Furniture R&D Applications Institute (Replaced by Mr. Hugh Burton on Aug. 1, 1976)	Schedule Start: July 1, 1973 End: September 30, 1978																					
Institution North Carolina State University Raleigh, North Carolina 27607	Funding see below NSF: Other:																					
Contributors/Collaborators Selected for specific projects from staff and faculty of North Carolina State University and other universities, and participating and sponsoring furniture firms.																						
User Advisory Committee (as of June 1976) Thomas B. Stanley, Jr., Chairman of the Board, Stanley Furniture J. Wayne Burris, President, Burris Industries Wesley E. Collins, President, Bernhardt Industries N. Hoke Fowler, Forest Products Industry Louis E. Hemebrick, Consultant J. Robert Philpall, President, Burlington House Furniture																						
Funding <table style="width: 100%; margin-top: 10px;"> <thead> <tr> <th style="text-align: left;"><u>Year</u></th> <th style="text-align: left;"><u>NSF</u></th> <th style="text-align: left;"><u>Industry</u></th> </tr> </thead> <tbody> <tr> <td>73-74</td> <td>\$ 98,700</td> <td>\$ 0</td> </tr> <tr> <td>74-75</td> <td>183,000</td> <td>40,430*</td> </tr> <tr> <td>75-76</td> <td>184,000</td> <td>60,000*</td> </tr> <tr> <td>76-77</td> <td>165,000</td> <td>107,150†</td> </tr> <tr> <td>77-78</td> <td>78,000</td> <td>250,000†</td> </tr> <tr> <td>TOTAL</td> <td>708,700</td> <td>457,580</td> </tr> </tbody> </table> <div style="margin-top: 10px;"> *Actual †Programmed </div>		<u>Year</u>	<u>NSF</u>	<u>Industry</u>	73-74	\$ 98,700	\$ 0	74-75	183,000	40,430*	75-76	184,000	60,000*	76-77	165,000	107,150†	77-78	78,000	250,000†	TOTAL	708,700	457,580
<u>Year</u>	<u>NSF</u>	<u>Industry</u>																				
73-74	\$ 98,700	\$ 0																				
74-75	183,000	40,430*																				
75-76	184,000	60,000*																				
76-77	165,000	107,150†																				
77-78	78,000	250,000†																				
TOTAL	708,700	457,580																				

Company, and Forest Products.

The Institute's organization, described in Appendix A, includes:

- An Advisory Board comprised principally of top level management of the sponsor companies to provide immediate counsel on the needs of the industry and on project priorities.
- A Board of Directors comprised of University administrators responsible for policy.
- A Technical Committee comprised of University faculty to provide technical expertise.
- A Project Task Force for each major project, comprised principally of representatives of the sponsor companies to provide guidance to the Principal Investigator for that project.

A brochure describing the Institute is included as Appendix A.

The Institute attempts to increase the rate of innovation in the furniture industry by reducing the time between the inception of an idea and its useful application. To accomplish this, the Institute, with industry participation, selects projects for joint research and follows them through the entire process from R&D to the production line. Throughout this process the Institute and its industrial partners work jointly on the research. In many instances the research is conducted in the individual plants.

The primary objective of the project is the demonstration of the effectiveness of Federal seed money incentives to stimulate lasting and mutually profitable industry-university R&D associations. The project is expected to be self-sustaining at the end of the funding period (September 30, 1978). The Institute estimates that an annual operating budget of approximately \$300,000 will be required to make it self-sustaining. Requirements for direct funding by the furniture industry are expected to be significantly reduced by funds

from royalties in processes and methods developed during the project. Project patents are assigned to NCSU and a portion of the licensing fees paid by individual firms is applied to the firm's contribution as an Institute sponsor. The Institute is currently exploring the possibility of obtaining funds from those industries supplying the furniture firms with materials and equipment. Contacts have been made with Eastman (Tennessee), Dupont, and 3M to determine whether funding support could be made available.

Initial plans called for obtaining 50-percent financial support from the furniture industry by the end of the third project year (1976). This goal has not been attained, partially because of the widespread slump experienced by the furniture industry in 1974-1975 and partially because a full-time director with practical experience in the furniture industry was not appointed until late 1975. Institute personnel are confident that sponsorship will pick up as the furniture industry emerges from the 1974-1975 slump. This confidence is shared by the Southern Furniture Manufacturers Association (SFMA), an organization that represents over 80 percent of the industry.*

A secondary project objective is the documentation and evaluation of the effectiveness of selected intervention techniques in overcoming barriers to innovation in the furniture industry. This aspect of the project, currently being developed by the Institute, will measure changes in attitudes toward research in terms of industry participation in joint research projects, industry requests for information, and industry use of the results of both NCSU research (Clark Chair Frame) and jointly sponsored research.

*Telephone conversation with Mr. Douglas Kerr, Executive Vice President Southern Furniture Manufacturers Association.

Anticipations of the project as stated in the cooperative agreement application are:

- an excellent experimental demonstration of the overall effectiveness of a governmental incentive to stimulate research and development use in a classic fragmented industry; and
- substantial conclusions and valuable guidelines regarding the most effective mechanisms to accomplish the development and adoption of beneficial innovations, specifically in the furniture industry, but with extrapolation of findings, as applicable, to other fragmented groups.

Major Institute programs during FY 1976 are listed below. Those marked with an asterisk (*) will continue in FY 1977.

1. Recruitment of Licensees for the Clark Chair Frame.* The Clark Chair Frame process, developed and patented by NCSU, involves the use of a bridge-frame construction for upholstered chairs consisting of two concentric curved plywood rims with spacer blocks or bridging blocks between the rims. Clark frames do not require the inherently weak dowel joints required for other processes, weigh 30 to 45 percent less than chairs using the traditional frame, and can be produced at cost reductions of 20 to 44 percent. At the present time, the frame invention is licensed to only one company and is currently being demonstrated to another. Several furniture plants have indicated interest in the process.

2. Fingerjointing. Historically, the furniture industry has not utilized fingerjointing, a woodworking technology for bonding small pieces into larger boards, commonly used in the construction industry. With the increasing costs and decreasing availability of high quality hardwood for use in the manufacture of furniture, the Institute initiated a joint university-industry

program to demonstrate the economic and engineering feasibility of finger-jointing in the manufacture of furniture. The use of this technology allows the utilization of low grades of lumber without excessive waste. As a result of Institute efforts, the woodworking machinery industry has developed a scaled down automatic fingerjointing system that is economically feasible for medium-sized plants. According to Hugh Burton, currently the Institute Director, the process is being accepted by the industry. To date, two plants have introduced this technology in the construction of interior frame parts and other uses.

3. Lumber Yield Improvement Program.* This program entails the development of conservation education/training programs for employees in the furniture industry. Upon completion, the program will become a service available from the Institute and will serve as an excellent means for recruitment of sponsor companies.

4. Furniture Finishing Using Robots.* This project, designed to demonstrate the feasibility of using commercially available robots in furniture finishing processes, was initially oriented toward the application of glaze (material used to impart the desired colors to exposed wood parts). However, it was determined that the limited labor savings resulting from this use would not justify the capital costs of the automated equipment. Consequently, the focus of the project was shifted to the use of automated equipment in the filler (powder-like material used to create a smooth surface prior to glazing), and glaze wiping steps in furniture finishing. These areas are being investigated because they offer promise of economically feasible use of robots. A vacuum wiping brush, developed under the program, is currently being used in a manual mode in the industry and has resulted in savings in materials and an improved product. Long-range plans call for investigating the feasibility of automating these processes. The Institute feels that the use of robots should

result in a savings in materials, reduction in manpower requirements, improved consistency of final product and substantially reduced turnover through the elimination of manual filler wiping and glaze wiping, both highly undesirable jobs.

5. Materials Handling Project.* This project seeks to develop the most economic storage system and procedures for different types of furniture manufacturing. It entails the use of a task force--Institute staff, sponsor companies' engineering staff, and undergraduate students--to conduct an in-depth study of warehousing and materials handling facilities.

6. Workshop for the Furniture Industry.* Workshops designed to transfer know-how to appropriate levels of plant management are conducted in such areas as production control, quality control, and energy conservation. The workshops are self-sustaining in that, with the exception of the salaries of Institute personnel, all expenses are covered by registration fees. The energy conservation workshops are being conducted in cooperation with the Southern Furniture Manufacturers Association. A news clipping (Appendix B) from the North Carolina Leader newspaper outlines the scope and extent of this workshop series.

7. Improved Moisture Cycling Performance in Dowel Joints. This project, under the supervision of Dr. R.B. Hoadley, University of Massachusetts, involves the study of dowel joints and the development of means of stress relief to reduce the incidence of joint failure. Dowel joints constitute the principal means in use today for fastening individual pieces in the construction of furniture.

8. Lumber Drying Improvement Program.* Current practice in air and/or kiln drying of wood used in furniture manufacture results in excessive degrading, loss in yield, and unnecessary costs. This project involves an evaluation of present operations, a description of actual operating parameters, and

feasibility studies for improved operation of this phase of furniture manufacture.

9. Carving and Embossing.* Machine embossing and carving of furniture are being studied. Use of mechanical methods should result in decreased costs and permit the utilization of lower-level skills.

Utilization Objectives

Any discussion of utilization of the results of this project must be made within the context of the two-tiered, potential user community. The first-tier user community consists of those government and private nonprofit agencies whose goals and objectives include the stimulation and funding of research and the adoption of innovations within industries which, for one reason or another, do not actively support or participate in research. Thus, NSF/RANN itself can be considered as being a first-tier user. Insofar as the first-tier user community is concerned, the output is a process that encourages participation in research and adoption of innovations within a particular industry or group of industries. Inasmuch as the Institute project is only one part of an overall NSF/RANN Experimental Research and Development Incentives Program, "Experiment in Cooperative Research," any evaluation of the utilization of the process must await completion and evaluation of all elements of the RDI experiment.

The second-tier of users is the furniture industry. The Furniture Institute program has a built-in mechanism for disseminating research results and encouraging use and adoption of such innovative programs that may ensue. Basic to the program is the involvement of individual furniture plants either as sponsors of the Institute, as participants in specific research projects, or as recipients of specific elements of information on some aspects of furniture manufacturing. Evaluation of utilization by the furniture industry is possible

through analysis of records and through discussions with sponsoring and participating industries.

Utilization Obtained

Based on an analysis of projects, documents and reports, and limited contacts with sponsoring and participating furniture manufacturers, the results of the research projects conducted by the Institute appear to be well utilized. The nature of the project, however, tends to limit utilization in that the results are not disseminated industrywide, but only to the sponsoring or participating firms. However, this facet of the project should not be construed as criticism, but rather as a factual description of the nature of the project itself, where success is measured by the support obtained from industry and royalties from patentable research results.

Reactions of reported users of the research are presented below.

Douglas Kerr, Executive Vice President
Southern Furniture Manufacturers Association
High Point, North Carolina

The Southern Furniture Manufacturers Association (SFMA) represents a major portion of the furniture industry in the United States.

Mr. Kerr feels that there is a very good relationship between his organization and the Institute. He feels, however, that this relationship could be made more effective through closer working relationships between the Institute and industry (represented by SFMA) and by a more active and vigorous program to promote and sell the Institute. Some specific areas suggested by Mr. Kerr lie in the research of methods by which the furniture industry can satisfy the requirements of the multitude of Government regulations affecting the industry. The research should be aimed at procedures and techniques for meeting

the regulatory requirements with the lowest cost impacts. As an example, Mr. Kerr cited the proposed promulgation of inflammability standards for upholstered furniture. Preliminary industry estimates show that the proposed regulatory requirements will result in 10 to 30 percent increase in manufacturing costs--the lower figure applicable to the large manufacturers and the higher to small units.

As a representative of the industry, Mr. Kerr feels that there is a definite need for the industry-university linkage represented by the Institute. The Institute has been meeting a need in assisting the individual furniture plants.

SFMA and the Institute have jointly developed an Energy Conservation Caucus. Presentations on the development of the program have been made to groups of 20 to 30 people. The first presentations were made in March of this year. Ten additional presentations are scheduled at various furniture centers in the South. The Caucus is intended to be self-sustaining through the payment of attendance fees. The program is popular with the furniture industry and is an excellent example of how industry, the university, and Government can work together in assisting industry in solving common problems.

In addition, the NCSU faculty participating in the Institute program has made and will continue to make presentations at SFMA techning meetings.

While he did not have any hard data to support his position, Mr. Kerr was of the opinion that the lack of increase in R&D funding within the industry during the past few years could be attributed to the slump that occurred in 1974, a slump from which the industry is just beginning to emerge. He felt that the slump has also been a major contributing factor in the reluctance of industries to individually become sponsors of the Furniture Institute.

All in all, Mr. Kerr feels that the Institute has been helpful to the industry, but thinks that it could be more helpful in addressing industrywide problems, e.g., making bunk beds safer, and solving construction problems in chairs.

Darrell Pierce
Plant Manager
Silvercraft Manufacturing Company
High Point, North Carolina

Silvercraft has been working closely with the Institute and is pleased with the relationship. The Institute has been responsive to their needs.

The Clark Frame process is currently being demonstrated in the plant. Production personnel are convinced of the increased strength that the process imparts to the chair frame. However, the sales department is resisting the change because the Clark frame is lighter than the conventional frame. The sales department feels that the weight of a chair as tested by the potential buyer is a factor that the buyer perceives as an indication of quality.

Silvercraft is considering becoming a sponsor of the Institute.

Wesley Collins
President
Bernhardt Industries
Lenoir, North Carolina

Mr. Collins has recently been elected Chairman of the Institute's Advisory Board and his company is a sponsor of the Institute. The Institute has been quite responsive to the company's needs. Bernhardt is currently participating in the lumber research project. This project is designed to increase utilization of lumber by improving processing and handling, and by preventing degrading during storage.

As a result of an in-plant workshop on production control, Bernhardt has changed its scheduling and is obtaining consulting assistance in this area

from an engineering firm. The company is also training members of the staff in industrial engineering procedures. Mr. Collins considers the efforts of the Institute through the workshop to be the primary reason for these changes and the formation of an embryo industrial engineering unit in the company.

Mr. Collins feels that one of the Institute's strong points is its ability to undertake research in areas not feasible for an individual furniture plant and then to share the results with the industry as a whole.

Mr. A. G. Hetzel
Plant Manager
Schweiger Industries
Jefferson, Wisconsin

Mr. Hetzel became aware of the Institute through numerous media: literature mailed by the Institute, a reader service card in a trade journal, and a friend's son who is an NCSU graduate.

Schweiger Industries is experiencing an increased demand for finished wood furniture. In order to update techniques and processes, the Institute spent two and a half days in the plant demonstrating techniques on how to better utilize existing equipment and to improve quality and quantity of production. The Institute's suggestions were adopted within a week of his visit and have resulted in improved manufacturing. No data are available as to potential savings because the changes have been in effect for only about a month. Mr. Hetzel feels, however, that the changes are resulting in a better quality product and will result in a cost savings.

As a result of the visit, Schweiger Industries has changed their procurement practices for abrasives. Previously, abrasives were purchased solely on a cost basis, e.g., lowest bidder. The Institute representative pointed out the advantages of settling on one abrasive manufacturer. This resulted in a more uniform quality of abrasive, but, more important, it made available to

Schweiger the services of the abrasive manufacturer's technical service personnel who, at no extra cost, provide consultation on the use of abrasives. As a result, Schweiger is realizing more effective and efficient use of abrasives.

Mr. Hetzel indicated that Schweiger Industries is quite interested in the Clark Chair Frame process and is seriously considering asking for a demonstration.

Mr. Hetzel views the Institute as an excellent source of information on furniture manufacturing. The two and a half day visit has broadened his and the engineering staff's horizons. In his opinion, the Institute has demonstrated ability to take highly technical information and translate it into terms understandable and usable at the manufacturing level.

The Institute visit also provided Mr. Hetzel with information on new furniture machinery and processes that are now being considered in the long-range (two-year) plan being developed by Schweiger Industries.

Mr. Charles Hyman, Jr.
First Vice President
Fox Manufacturing Company
Rome, Georgia

and

President
Charles Manufacturing Company
Dothan, Alabama

While at the Rome, Georgia plant, Mr. Hyman was involved in a series of inplant seminars conducted by the Furniture Institute. At these seminars (four over a period of several months), managers of all phases of operations--production, quality control, sales, etc.--were brought together. Managers from the Dothan plant attended two of the seminar sessions. At the seminar, the problems of the various departments were discussed. As a result, better working

relationships were formed and new channels of communication opened. Both Fox and Charles have continued the seminars on an informal basis.

The Rome plant is currently involved in the Institute's lumber yield program.

Mr. Hyman learned of the automatic stain wiper when he attended the recent Advisory Committee meeting, and is interested in it being developed at the Institute.

Mr. James Thornton
Director of Manufacturing
Stanley Furniture Company
Stanleytown, Virginia

Mr. Thornton reported that his firm is working with the Furniture Institute on projects on lumber yield, materials handling, and glazing/vacuum cleaning. The latter project is examining the potential of using automation equipment for applying and wiping glaze materials used in the manufacture of certain items of furniture. Results to date show promise of improving the highly undesirable working conditions associated with glazing and finishing operations. Stanley and the Institute are also currently conducting tests on chairs.

Stanley Furniture participation in the materials handling project has resulted in improved operations in their lumber handling and storage activities. This educational program has resulted in savings of materials and human resources. Mr. Thornton stated that he could not quantitatively assess the impact of the improved materials handling procedures because they were implemented along with other changes. He did state that the Furniture Institute activities in this area made a significant contribution.

Mr. Thornton is very much encouraged over the potential of the Furniture Institute in assisting the industry in the improvement of operations through joint R&D efforts. He feels that the recent shift in emphasis of the Institute

projects from solely industry-originated to Institute-originated is a good thing. He attributes the limited response in the past to both economic setbacks in 1974 and, until recently, to the absence of a full-time Institute Director. An outsider who is knowledgeable in furniture operations is more apt to recognize areas in which improvements are needed than one who has been closely associated with and, in many instances, has a vested interest in the process. In Mr. Thornton's opinion, the full-time Institute Director fills that need admirably.

Features

There are a number of factors that appear to influence utilization of the results of the Furniture R&D Applications Institute experiment. An enumeration must include:

- The experimental nature of the program--emphasis is on testing the hypothesis that realignment of traditional institutional arrangements will enhance innovation.
- The well-defined experiment duration--knowing that NSF/RANN support for the Institute will terminate at the end of the five-year grant emphasizes the need for the creation of future income and the development of permanent university/industry relationships.
- The caliber of key Institute personnel--the appointment of an Institute Director and industry liaison personnel with extensive and varied experience in the furniture industry facilitates the translation of technical research into a form that is more acceptable and understandable to the furniture industry.
- The licensing arrangements--the policy that licensing fees paid by

participating firms can be applied to sponsorship fees is an incentive to sponsorship once a company adopts a process developed by the Institute.

- The stature of NCSU--NCSU, the State's first land-grant institution, has engendered a research and extension orientation through cooperation with business, industry, government agencies, and other universities. Through its Schools of Engineering and Forest Resources, NCSU has developed close and cordial relationships with the furniture industry.
- The location of the Institute--NCSU is located within commuting distance of High Point, N.C., one of the most concentrated furniture manufacturing centers in the United States. In 1971, 50 percent of the furniture manufactured in the country was produced within 300 miles of High Point.
- The Advisory Board--composed of top-level management representatives from sponsoring companies, is well suited to provide advice on the industry's needs and priorities. In addition, it serves as a vital linkage between the University and the industry.
- The program management--no significant faults were attributed to NSF/RANN management in response to inquiries on this matter. All evidence points to an effective, constructive approach to supervision of the Institute project by NSF.
- The use of the Institute as a central repository for new developments and technology--the concentration in one location of information of new developments and technology in the furniture industry facilitates the transfer of a technology in that it provides the furniture industry with a focal point for obtaining such information.

- The joint nature of the project--the conduct of research projects in the furniture plants themselves serves as an excellent means for demonstrating the value of research and as a means for transferring research know-how to industry personnel.

Conclusions

Despite having not met its objective of a minimum of 20 industrial sponsors at the end of the third grant year (there were seven as of June 1976), there are indications that sponsorship will increase so that the Institute will be fully funded when Federal funding terminates in 1978. All of the nonsponsoring furniture firms contacted during the preparation of this case study gave as the primary reason for their nonparticipation as sponsors, the recession of 1974 and 1975. This observation is supported by the Southern Furniture Manufacturers Association. The Institute did meet its goal of extending its support base outside the southeast area. One of the current sponsors, AMSTORE, is based in Michigan. Schweiger Industries, a Wisconsin firm, has indicated that they are seriously considering becoming a sponsoring firm.

The search for an Institute Director and industry liaison personnel came to fruition in 1975. The delay in appointing such full-time personnel was necessitated by the desire of obtaining personnel with industry experience and the ability to serve as an effective link between the University and the furniture industry. As a result, sponsor recruitment activity on the part of the Institute was somewhat limited during the first two grant years. The appointments in 1975 of Mr. John Markle as Institute Director and Mr. Hugh Burton as principal industry liaison have resulted in increased activity of the Institute

in obtaining industry support. As of August 1976, Mr. Markle has returned to the furniture industry. The position of Director has been assumed by Mr. Burton.

The licensing of the Clark Chair Frame process in one firm, the current demonstration in another, and the interest shown by other companies should expedite the adoption of this process. However, one furniture manufacturer has indicated one barrier to the acceptance of the Clark Chair Frame. The obstacle is the resistance on the part of sales personnel, who maintain that the lighter weight of the chair made possible by the Clark design is perceived by some consumers as being an indicator of low quality. A marketing survey appears to be indicated to determine consumer opposition to the lighter chairs. If such an opposition is determined to exist, a properly designed sales and consumer education program should be initiated to change these attitudes.

Other programs, e.g., the lumber quality and yield improvement program and the vacuum wiper program, have been adopted by some in the industry. This is also an indication of increased interest in the Institute that could lead to sponsorship.

Most of the Institute's success has been realized in the past year. As word of this success spreads, the inherent imitative pattern of the furniture industry should attract progressively more Institute sponsors.

The Institute performs important functions for the furniture industry. It also facilitates innovation in the furniture industry by gathering information about problems already recognized by firms in the industry, calling attention to problems not yet recognized by developing innovative solutions that exhibit significant advantage over current products and processes, and by disseminating information about these innovations in a persuasive way. It provides firms in the industry with a means of aggregating industry resources toward a collective

innovative effort. It allows each firm access to a group of professionals in the problem recognition, awareness, and developmental phases of the adoption process. Finally, the Institute provides a mechanism for investigating the potential benefits of innovative solutions at low risk to individual firms, and for communicating these benefits. These important functions which should foster a more vigorous innovation posture in the furniture industry, were not adequately performed prior to the establishment of the Institute.

There are, therefore, high expectations that the Institute will meet its terminal goal of full industry support at the end of the grant period in 1978.

Appendix A

Furniture R&D Applications
Institute Descriptive Brochure

TECHNICAL COMMITTEE OF THE FURNITURE INSTITUTE

- A.C. Barefoot Head of the Division of University Studies & University Coordinator for Environmental Studies.
- John Barry Project Leader, Lumber Yield Improvement Program.
- H.A. Burton Furniture Manufacturing Specialist Associate Dean of Engineering for Extension.
- E.L. Clark Furniture Extension Specialist Industrial Engineering and Industrial Extension Services.
- V.M. Foote Associate Professor and Director of Product Design.
- R.C. Gilmore Associate Professor, Wood and Paper Science.
- I.S. Goldstein Head, Wood and Paper Science.
- D.S. Hanby Director, Textiles Extension & Continuing Education.
- S.J. Hancock Extension Instructor, Specialist, Extension Forest Resources.
- F.D. Hart Professor, Mechanical and Aerospace Engineering.
- A.L. Piek Professor, Furniture Manufacturing & Management and Industrial Engineering.
- W.A. Smith Head, Industrial Engineering Department.
- M.R. Sparks Area Representative, Industrial Extension Services.
- E.P. Stuhel Professor, Chemical Engineering.

For information and a fee schedule, write or call:

JOHN J. MARKLE
Director

Furniture R&D Applications Institute
North Carolina State University
P.O. Box 5511
Raleigh, North Carolina 27607

Telephone: (919) 737-3338

WHAT KIND OF PROJECTS DOES THE FURNITURE INSTITUTE WORK ON?

The Furniture Institute attempts to bring about conservation of materials, improvements in the product and economy in manufacturing and distribution. The selection of specific projects is done in close consultation with the furniture industry. The diversity of the Institute's work is illustrated by some of the projects now underway:

Manufacturing methods for veneer based upholstery frames.

In-plant workshop in production scheduling and control.

A technological and economic study of the potential of fingerjointing in the furniture industry.

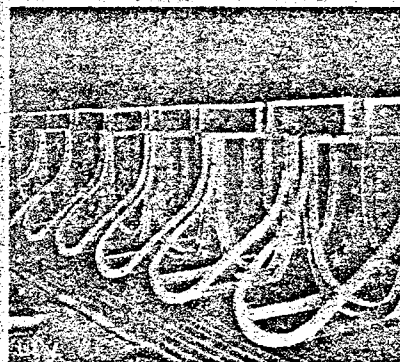
Lumber Yield improvement program.

Automation of furniture finishing operations through the use of robots.

Material handling.

Lumber yard and dry kiln projects.

New projects will be added each year, concentrating on the most urgent needs of the industry and the best opportunities for improvements.



Reproduced from
best available copy.

FURNITURE R&D APPLICATIONS INSTITUTE

IN COOPERATION WITH THE
NATIONAL SCIENCE FOUNDATION

AN INDUSTRY UNIVERSITY COOPERATIVE PROGRAM

AT NORTH CAROLINA STATE UNIVERSITY

SUPPORTED BY THE OFFICE OF
DEAN FOR RESEARCH

WITH MAJOR FACULTY AND TECHNICAL
SUPPORT FROM

SCHOOLS OF:
**DESIGN
ENGINEERING
FOREST RESOURCES
TEXTILES**

ADVISORY BOARD OF THE FURNITURE INSTITUTE*

Thomas B. Stanley, Jr.
Advisory Board Chairman
Chairman of the Board
Stanley Furniture, Stanleytown, Virginia

J. Wayne Burris
President, Burris Industries,
Lincolnton, North Carolina

Wesley E. Collins
President, Bernhardt Industries,
Lenoir, North Carolina

Joseph T. Frye, Jr.
Chairman of the Board, Athens Home
Decor, Athens, Tennessee

Louis E. Hjalmarich
Consultant to H.J. Schelrich Co.,
Louisville, Kentucky

J. Robert Philipott
President, Burlington House Furniture,
Lexington, North Carolina

*AS OF OCTOBER 1975

WHAT IS THE PURPOSE OF THE FURNITURE INSTITUTE?

The purpose of the Furniture Institute is to increase the rate of innovation in the furniture industry. The objective is to reduce substantially the time between an idea and its useful application in the industry. To accomplish this, the institute will follow through the entire process of research, development and application of a given project, working closely with industrial partners.

The target industry is the household, institutional and commercial furniture industry, i.e., manufacturers of case goods, occasional and upholstered furniture.

BOARD OF DIRECTORS OF THE FURNITURE INSTITUTE

Earl G. Drossler, Chairman
Vice Provost and Dean for Research,
NCSU

David W. Chaney
Dean, School of Textiles, NCSU

Eric L. Ellwood
Dean, School of Forest Resources, NCSU

Ralph E. Fadum
Dean, School of Engineering, NCSU

William L. Turner
Vice Chancellor for Continuing
Education and Public Service, NCSU



WHO RUNS THE FURNITURE INSTITUTE?

The Furniture Institute is an integral part of North Carolina State University at Raleigh. It has an Industry Advisory Board that gives counsel on what projects are to be pursued. It has a Board of Directors that determines policy and methods of operation. The Director of the Institute works with the technical staffs of the participating furniture manufacturing firms and the faculty involved in the projects aimed at accomplishing the goals set by the two boards. Providing major faculty participation are the University's School of Engineering and School of Forest Resources. In addition, the School of Textiles contributes to Institute objectives.

WHAT SERVICE DOES THE FURNITURE INSTITUTE OFFER?

The Institute offers short courses, in-plant workshops, cooperative technical programs, conferences and seminars, as well as technical counseling and information.

WHAT DO FURNITURE INSTITUTE SPONSORS OBTAIN?

The important advantage to the sponsor companies is that they participate in the selection of specific projects and the execution of these projects. The Institute is a joint venture between the Furniture Industry and North Carolina State University. By being a participant in a project, a company obtains experience in and understanding of the technology involved. Working closely with the sponsor company's personnel, the Institute staff provides the necessary follow-through that will improve the likelihood of success in the application.

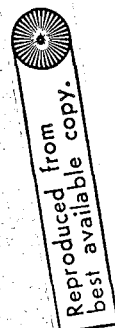
The sponsors receive detailed reports on the projects; they are invited to attend conferences organized by the Institute; they are also invited to on-campus and in-plant demonstrations; they are able to obtain many Furniture Institute services at advantageous rates.

The Furniture Institute staff is committed to the well-being of the furniture industry and makes a sincere effort to stay on top of all new developments.

HOW IS THE FURNITURE INSTITUTE FUNDED?

The Furniture Institute is funded with a \$708,700 grant awarded by the National Science Foundation July 1, 1973. The grant covers the Institute's operations fully for the first year; approximately 80% for the second year; 70% for the third year; 50% for the fourth year and 20% for the fifth year.

Additional funding comes principally from Industrial sponsors of the Institute.



Appendix B

Newspaper (North Carolina Leader)
Report of NCSU Furniture Institute Activities

Page 14

North Carolina Leader

June 15, 1976

NCSU profs 'on the road'

Two North Carolina State University engineers with an active interest in energy conservation techniques will take to the road June 15 to present a unique workshop program for furniture manufacturers in seven states.

Profs. Herbert M. Eckerlin and Albert S. Boyers of the mechanical and aerospace engineering faculty are instructors for "The Energy Caucus for Furniture Manufacturers" workshop co-sponsored by the Southern Furniture Manufacturers Association and the NCSU Furniture R&D Applications Institute.

The workshop program is aimed at presenting practical ways of implementing energy conservation methods directly geared to the machinery and

buildings used in furniture manufacturing.

The workshop emphasizes sessions in which each participant has an opportunity to learn basic concepts through individual exercises and case studies. Participants are encouraged to bring specific problems from their own plant for group discussion.

Dates and locations of the workshop program now scheduled are: June 16, Hickory; June 17, Martinsville, Va.; June 21, Tupelo, Miss.; June 22, Fort Smith, Ark.; June 24, Lenoir/Morganton; June 28, High Point; July 14, Newton/Conover; July 15, Morristown, Tenn.; July 19, Louisville, Ky.; Aug. 26, Atlanta, Ga.

Dr. Eckerlin, who has long-time experience in the design and operation of special purpose heat recovery systems, is author of numerous technical papers and holder of 11 basic patents in fluidics and heat exchange design.

Prof. Boyers, a mechanical engineer whose major work in recent years has been in the development of energy conservation techniques, has been instrumental in implementing numerous NCSU engineering extension activities for industry in various aspects of energy. These activities include technical assistance, short courses, workshops, and conferences.

For the last two years, both engineers have conducted over 100 energy audits for North Carolina business and industry.

Reproduced from
best available copy.





RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 33

INNOVATION CENTERS

CARNEGIE-MELLON UNIVERSITY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
UNIVERSITY OF OREGON

Case Investigator:

R. M. Burger

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

J. Kohl

Department of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina 27607

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

INNOVATION CENTERS

Introduction and Summary

"The Breakdown of U.S. Innovation"* is the title of a recent article that voices a growing concern of the nation's leaders. Based on a decrease in the number of patent awards, defensive attitudes in corporate research, a shrinking share of government and private funds for research, and other indicators, an erosion of innovation has been discerned that bodes ill for this nation's political and economic future. The causes of this stricture on innovation are believed rooted in governmental, business, and academic patterns that tend to preserve present practices and products, and to suppress the creative processes that nurture entrepreneurship. Only by changing these patterns can an environment receptive to innovation be created.

The NSF/RANN Innovation Centers Experiment on which this utilization case study is focused attempts to determine whether changes in educational patterns can produce increased innovative capability in students. Three innovation centers have been created at universities. These centers offer courses in entrepreneurship and innovation, expose students to the entrepreneurial process, and actively promote innovation as an integral part of the academic regimen. The centers are located at the Massachusetts Institute of Technology (MIT),

* Business Week, February 16, 1976

Carnegie-Mellon University (CMU), and the University of Oregon. More information on the centers is given in table 33-1.

The Innovation Centers Experiment is based on three hypotheses: (1) technological entrepreneurs can be recognized, stimulated, and assisted in university programs; (2) innovation centers can be viable activities in an academic setting; and (3) academic innovation centers can serve as vehicles for idea or product commercialization. The experiment will be a success insofar as these hypotheses are proven. Utilization, in the broadest sense, will occur when the centers become permanent components of the university programs and are replicated at other schools.

In addition to the ultimate concept, utilization through replication, there is a number of subsidiary objectives and products--each of which has potential for utilization. These outputs are important--students, entrepreneurs, products, companies, jobs, ideas, and demonstrations of various approaches to innovation and entrepreneurship.

The three centers are focused on different facets of the innovation process. At MIT, the focus is on supplemental educational experiences in idea generation and development of new products or services; at CMU, it is on new venture initiation; and at Oregon, idea and invention evaluation and transfer to the commercial sector. Each center, however, can and does participate in a full range of these activities.

The fact that the three centers are elements of an overall experiment that was created, designed, and managed by NSF is a unique feature of this case study. This circumstance requires that the Program Manager, Mr. Robert Colton, be an active participant in all phases of the experiment, and this is the case. NSF has employed a flexible contractual instrument, the cooperative agreement with the parent institutions of the Centers; supporting contractors;

Table 33-1
PROJECT INFORMATION

Project Title: Innovation Centers Experiment	Grant/Contract No. Oregon CG-00001 MIT CG-00002 CMU CG-00003
RANN Program Manager Mr. Robert Colton	RANN Program Area Experimental R&D Incentives
Principal Investigator(s) Dr. Gerald G. Udell - Oregon Prof. Yao Tzu Li - MIT Prof. Dwight M. Baumann - CMU	Schedule Start: June 1973 End: September 1978
Institution University of Oregon Massachusetts Institute of Technology Carnegie-Mellon University	Funding NSF: Oregon \$793,650 MIT \$1,125,000 CMU \$1,075,000 Other: Oregon - None MIT-Client contracts, gifts and royalties CMU - \$47,000 from CMU
Contributors/Collaborators Oregon - Western Inventors Council MIT - Industrial clients via contracts CMU - None	
User Advisory Committee Oregon - Western Inventors Council serves this purpose MIT - Advisory Board of the Innovation Co-op (9 members, MIT and Industry Innovation Education Council - 13 faculty members) CMU - Advisory Board (Business and community leaders) Venture Evaluation Board (CMU faculty)	
Precursor Activities All of the universities had prior courses in entrepreneurship and innovation in some form. At Oregon, a relationship had already been established with the Western Inventors Council. At MIT, Dr. Li had been active in establishing relevant academic programs. At CMU, the Center for Entrepreneurial Development was established in 1971 and received initial funding from the University.	

and close and continuous liaison with the Centers to assure that the experiment remains an entity rather than become a group of projects. The overall results of the experiment, and their utilization, have not yet developed--this will come with time. At this point, utilization is primarily associated with the separate research products developing from the individual centers.

Since the Innovation Centers Experiment has run but three years of its five-year duration, the ultimate measures of utilization--permanence and replication, have not been demonstrated. However, substantial and noteworthy utilization has occurred. Students have become entrepreneurs; products and companies have been created; attention has been attracted to the innovation challenge; and each of the centers, in a different mode, anticipates success.

The nature of this experiment and the goals it has set are bathed in the complexity of a broad set of education and economic development aspirations. Each participant, beneficiary, or observer sees a different facet and finds a different message. The individual centers derive their unique characters from their directors and their environments. Each produces different products and develops a different constituency. A brief study, such as being reported here, can only sample and hope to reflect the essence of the experiment. The essence reported is that the products of the experiment are being used--it appears that utilization will increase and that the Innovation Centers Experiment will make significant contributions toward satisfaction of a spectrum of national needs.

Research Description

The Innovation Centers Experiment originated in the Experimental Research and Development Incentives Program of NSF which is now assigned to the Directorate for Research Applications. Arthur A. Ezra and Robert Colton of NSF provided

the overall experiment design. An open solicitation attracted a number of proposals from which the three funded projects eventually resulted. A generalized functional model for an innovation center as conceived for the experiment is shown in figure 33-1. Each of these centers has a different structure and different specific objectives. Information on each is given in Appendix A, based on information supplied by NSF and the Centers.

Mr. Colton is the NSF Program Manager and has been since negotiation of the awards. In this, his role is different from that of the usual NSF program manager. The Innovation Center Experiment is considered as an entity with each project tailored to the experiment design, and modified, as necessary, to fit the integrated plan. Each project is based on an innovative "cooperative agreement" that allows considerable flexibility in carrying out the experiment. Because of these features of the experiment, the Program Manager has been very active in creating, designing, and implementing the individual projects. This has involved almost continuous participation in the separate projects as well as a more formal quarterly joint meeting with the directors, support by an evaluation and planning contractor, and analyses and studies by NSF staff.

A significant aspect of the Innovation Centers Experiment is the provision of full funding for the five-year experiment and recognition that on the termination of the experiment, NSF funding will cease. For the centers to remain active beyond that point, income from other sources must become available. Each of the centers has adopted a different approach to continued funding. At CMU, services provided to new ventures are repayable with interest, and stock in the companies is assigned to the Center. In addition, the Center is permitted to accept grants and gifts from foundations or government agencies. Although revenue from these sources, to date, has not materialized, Dr. Baumann believes the potential for CED support is developing.

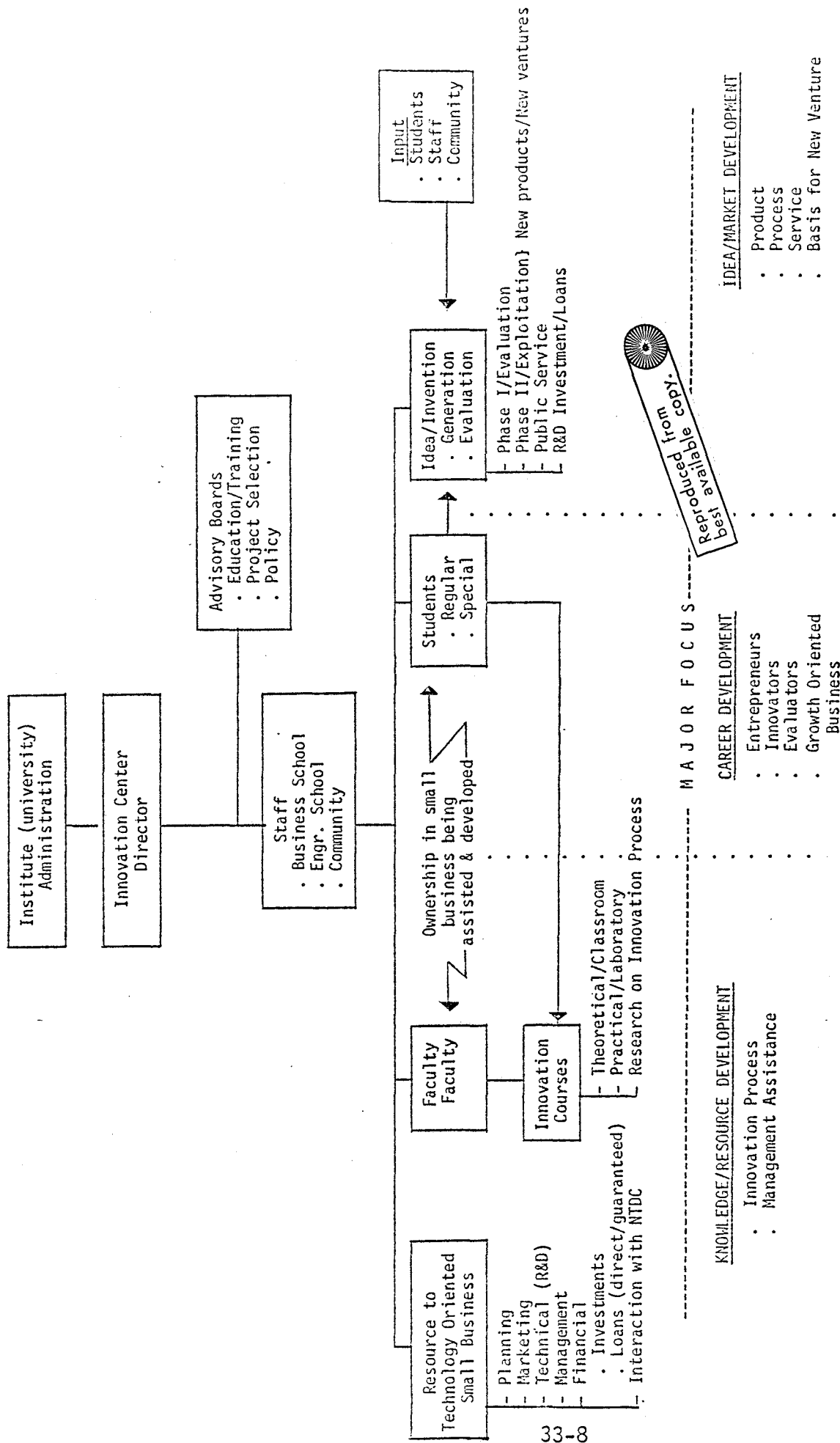


Figure 33-1. Innovation Center Function Model (obtained from NSF)

At MIT, income is being built up from royalties of inventions made in the Innovation Center and from gifts and contracts. Income from all sources was in excess of \$28,000 in fiscal year 1975 and \$140,000 in fiscal year 1976. Total non-NSF income received to date is \$201,820 in royalties, gifts, and contracts. The possibility of other funding mechanisms is being considered.

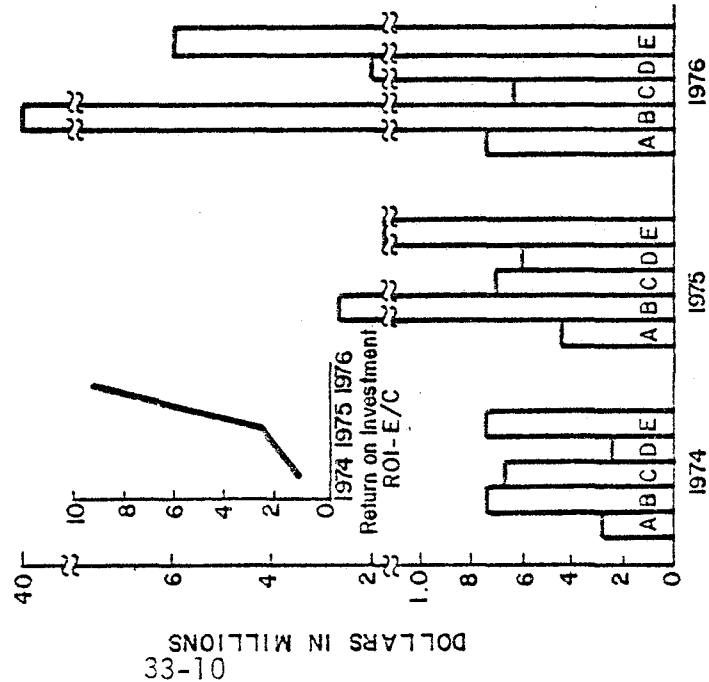
At Oregon, although fees are required for invention evaluation and are being accumulated in a trust by the Western Inventors Council, and royalty agreements are negotiated for products being developed, these will never be adequate for Center support according to Dr. Udell. In its present mode of operation, a definite need for continued substantial subsidization is foreseen, and the Center--by development of a mechanism for public service, is attempting to build a constituency among independent inventors and industry that will assure continued support after the NSF funding terminates.

It is noteworthy that each center is bound by an individually negotiated agreement in which patent rights on innovations in the centers can be shared by the inventors and the centers, subject to specific negotiated terms. Income derived from patents or from ventures by the centers will be reimbursed to NSF should the centers cease to exist. This is limited to an amount not to exceed that of the grant, and applies for a period of ten years after termination of the grant. This statement is based on a copy of the Oregon agreement, but, from the discussions with Center Directors, apparently applies to all three centers.

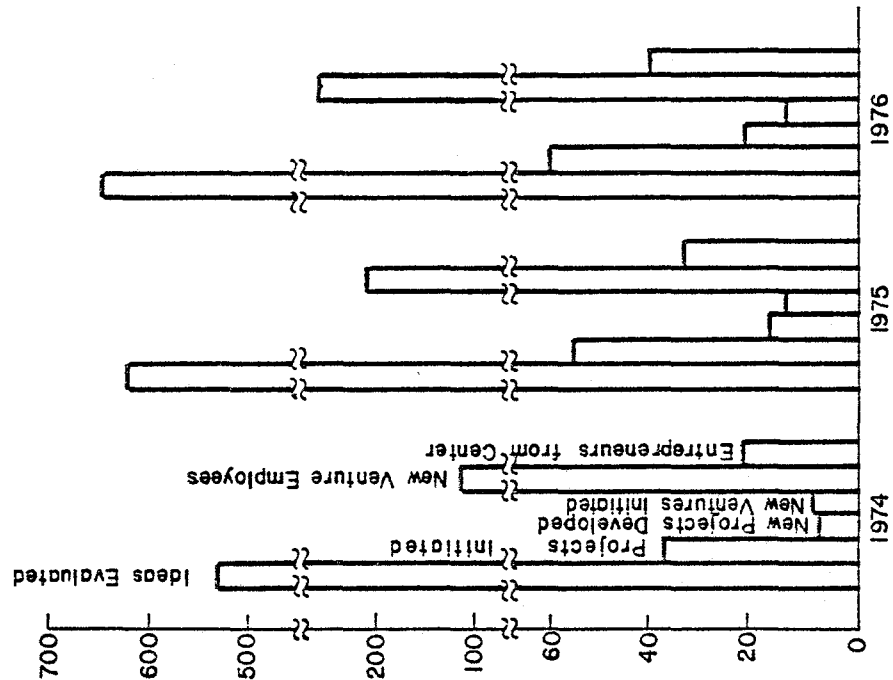
There is opportunity for considerable latitude in the interpretation of data on the Innovation Centers Experiment. This results from the continuing interaction of the multiplicity of factors involved in operation of the centers and creation of ventures. A compilation of data provided by the NSF Program Manager is given in figure 33-2. These data illustrate the diversity of

RESOURCES DEVELOPMENT AND RETURN ON INVESTMENT

- A. Private Venture Capital Invested.
- B. New Venture Sales
- C. NSF Funding.
- D. Estimated Federal Taxes from New Venture Employees & Profits.
- E. Estimated Federal Taxes from Distribution of Wages & Profits.



IDEA DEVELOPMENT



CAREER DEVELOPMENT

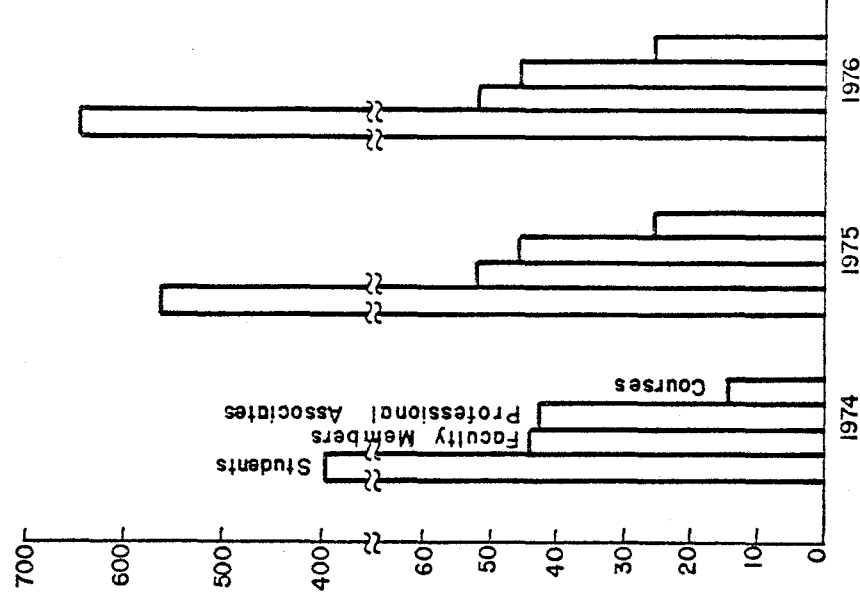


Figure 33-2. Summary of Experiment Results for Three Centers.

activities in which the Centers have participated and indicate a continued growth in the chosen measures of Center activities.

A listing of innovation center cases is given in Appendix B. For certain of these cases, the full spectrum of center activities--from idea generation to company organization--was involved. For others, more limited services were provided. These cases also represent all stages of development--from an evaluated product concept to successful production. The list is meant only to give an indication of the scope, variety, numbers, and potential of innovation center cases.

Based on conversations with the Center Directors, a brief discussion on each center follows.

At Carnegie-Mellon, Dr. Baumann emphasizes that the Center is focused on people, not ideas. The Center for Entrepreneurial Development (CED) trains people to make things happen. In the process, they must take risks and most people will only take risks with their own ideas. CED places much importance on the role model--by demonstrating success in existing ventures, students will be encouraged to become entrepreneurs. CED, Inc. has been organized as a tax exempt organization to provide a legal shelter, management services, and facilities for new ventures. Among the new ventures incubated in CED, Compu-Guard is the most outstanding example. It assembles and sells security and data systems that utilize microprocessor controlled communications links over existing power lines. Dr. Baumann notes that eight dollars in taxes have been created through new ventures for every tax dollar spent by CED.

At the MIT Innovation Center, the resources of the Institute are of paramount importance. The expertise available in its faculty, the caliber of the students, and the facilities provide a powerful environment for innovation. Dr. Y.T. Li, who is a successful entrepreneur himself, places emphasis on

market assessment of ideas before development, but only in the context of the Innovation Center as a supplemental education experiment. The totality of Innovation Center operations includes the education program with courses in innovation and entrepreneurship, laboratories for a learn-by-doing approach to invention development and new enterprise development, and the Innovation Co-op where selected ideas are developed to where they can be presented to industry or potential inventors. The Advisory Board of the Innovation Co-op is made up of senior MIT and industry individuals and must approve all proposed Co-op projects. Two starting points for the innovation process are apparent--one in which the external need (and market) is externally recognized and innovation is directed to filling that need; and a second wherein an individual student invents in response to an internally perceived need, and a market analysis indicates that commercial success is possible. At MIT, the first type, in the form of industry funded Co-op projects, is now the most utilized pathway to innovation.

Dr. Udell at Oregon has emphasized the development of an idea evaluation system that responds to the needs of independent inventors. He perceives this development as still being perfected even as it is being applied. Although clients are being satisfied, Dr. Udell is not satisfied that these needs are really being met. A full-time technology transfer agent has recently been added to the Center to increase commercialization efforts. The objective is to develop the system and procedures during the course of the NSF support. If the Center is successful in doing this, other support may be obtainable based on the public service being performed. Dr. Udell recognizes clearly that fees and returns from licenses and royalties will not support the Center at the end of the experimental period. However, by development of an effective public service function, he expects to develop a constituency that will lead to

further support from either State or other Federal agencies.

Many details of the history and operations of the individual centers cannot be included here because of space limitations. One may note, however, some of the problems with which each of the centers is faced. At MIT, there are difficulties in attaining peer acceptability in the academic structure for the Innovation Center activities and in avoiding the overlapping of existing programs. Laboratory space for the Innovation Co-op is inadequate--at present a departmental laboratory is used and both space and equipment are minimal. At Oregon, the initial idea evaluation procedures did not work well, requiring excessive time of the evaluators and not satisfying the idea originator. A new evaluation system based on a more systematic evaluation form and computer analyses is being developed and appears to work well. The response of the users is good and more ideas are being evaluated. At CMU, the development of the "form" of the Center detracted from its substance during the early period. Now that operating procedures are defined, and the tax exempt status of the corporate structure, Center for Entrepreneurial Development, Inc., has been attained, efforts on the gestation of new ventures are increasing.

The Innovation Centers Experiment has received much attention from the mass media, and there has been much dissemination of information by personal contacts. At the Engineering Foundation Conference on "Technology Transfer Via Entrepreneurship" in Henniker, New Hampshire in July of 1975, an overview of the experiment was highlighted. Articles on the experiment have appeared in the Wall Street Journal, The Christian Science Monitor, the National Observer, local newspapers, and business and technical journals, the centers, and the products of the centers. Although the operating reports of the centers do not receive wide distribution, the publications and talks, and the large number of visitors to the centers have succeeded in disseminating information. The NSF

Program Manager reports that he has played an active role in this dissemination, serving as an information conduit to many potential users in government and in academic organizations. This flow of information is expected to increase as the experiment progresses.

Utilization Objectives

The Innovation Center Experiment is described by the NSF Program Manager as an experiment in training potential entrepreneurs and innovators.* It is also designed to test the effectiveness of limited government subsidy of university centers in the following areas:

- evaluating technology and R&D results,
- developing new products and services,
- providing assistance to independent inventors, and
- establishing new business ventures.

In addition, each center has a unique focus expressed as follows:

- At MIT, the focus is on a learn-by-doing approach wherein ideas are generated and developed into new products or services that can be licensed to an existing company or be the basis of a new venture.
- At CMU, the focus is on new venture initiation and support to the stage where the business can qualify for venture capital assistance.
- At Oregon, the focus is on idea or invention evaluation and upon transfer of technology from the independent to the entrepreneurial and corporate sectors.

This multi-objective scenario results in a commensurate multiplicity of possible types of utilization. At one level, utilization results when

* R.M. Colton and G.G. Ude11, "The National Science Foundation's Innovation Centers - An Experiment in Training Potential Entrepreneurs and Innovators," J. Small Business Management, Vol. 14, April 1976, pp. 11-20.

entrepreneurial activities are created or catalyzed by the centers' activities, i.e., new successful companies or products are created. At another level, utilization occurs when students benefit from participation in courses or laboratory activities associated with the centers. Utilization also takes place when enterprises are advanced to where venture capital is attracted to them. The Centers Experiment will be utilized by industry when ideas or procedures originating in the experiment are adopted by industry. Finally, the ultimate level of utilization will be realized when the center concept is adopted as a model by policy makers for successful realization of educational, entrepreneurial, innovational, or other objectives.

There is thus a multiplicity of potential users and all of these are represented in one way or another in the Centers Experiment. Participation in center activities as an idea originator, innovator, client, entrepreneur, or educator is a prime method of dissemination. The nature of the experiment is such that many publications and considerable attention by the popular media have resulted primarily through the initiative of the Program Manager. Relatively few scholarly publications have been prepared, but, as typified by the cited article in the Journal of Small Business Management, these publications are increasing, according to Mr. Colton. The Center Directors report that many visitors, including a number from other countries, have been attracted to the centers. Mr. Colton also reports a large volume of interactions with academicians and policy makers motivated by a desire to replicate one or another of the activities being tested in the centers. Thus, dissemination--even with a paucity of center generated reports, is apparently effective and far reaching, although perhaps only to certain potential user populations who have learned about the experiment.

Utilization Obtained

The diversity and numbers of potential users of the Innovation Centers Experiment have limited this utilization study to a sampling of the various user classifications. The responses provide an indication of the general nature of the utilization attained, but are insufficient to draw specific conclusions on the various types of uses. Even though the various users view the Innovation Centers from vastly different perspectives and voice a broad spectrum of needs, they universally support the experiment. Criticism is primarily directed to detailed facets, e.g., "The innovation center did not provide me with enough information on marketing a product," or "The evaluation service was not directed to my specific needs." There is, naturally, a spectrum of experiences: ventures that have not been successful; ideas that have not met the criteria for further development; ideas that met the criteria and were developed, but did not meet with success; and students who--though exposed to the center experience, have not become entrepreneurs. The sample of interviews focuses on utilization that has been obtained. Other evaluations of this experiment will attempt to provide in-depth data and analysis of the experiment results*.

Entrepreneurs

An obvious and very visible classification of users is those entrepreneurs who, through involvement in a center or service by a center, have attained some

* Denver Research Institute is under contract to NSF to monitor the status and prepare an evaluation plan for the Innovation Centers Experiment.

measure of satisfaction or success. The presidents of three corporations that have benefited from the program were contacted: Dr. Klein of the Klein Corp., Dr. Eckhardt of ECD Inc., and Dr. Wadhvani of Compu-Guard. Dr. Richard Longini, an idea originator whose product is being commercialized with the assistance of the Center for Entrepreneurial Development at Carnegie-Mellon; and Mr. Don Alanen, a participant in a venture effort associated with the Oregon Center for the Advancement of Inventory and Innovation, were also interviewed.

Klein Corporation
Cambridge, Massachusetts

Mr. Gerry Klein
President

Mr. Klein, as a student at MIT, participated in courses in entrepreneurship. He noted that these courses were excellent and reoriented his career goals. With other students and guided by the faculty, a novel approach to the design of racing bicycle frames was conceived before the Innovation Center was started and, subsequently, submitted as a proposal to the Center. With Center support, the development has proceeded to where a corporation now exists, outside financial support is available, and success--according to Dr. Klein, is at hand.

Mr. Klein stated that many mistakes had been made in getting underway, primarily those related to management, financing, and marketing; however, he felt that it may be necessary to make mistakes and learn from them in order to evolve a viable business operation. In this particular instance, he did not believe the Innovation Center provided guidance that was as strong with respect to the business and marketing factors involved in starting a new business as it was for the technical aspects of the product. However, without the entrepreneurial courses and support of the Center, this company would not have been created.

ECD, Inc.
Cambridge, Massachusetts

Mr. Richard Eckhardt
President

The company of which Mr. Richard Eckhardt is President, ECD, Inc., represents a different set of circumstances. The ideas and the development of the products did not take place in the Innovation Center. However, Mr. Eckhardt stated that the entrepreneurial courses which he took were extremely beneficial; in fact, the best courses that he had at MIT. The evolution of ECD, Inc. has benefited also from close contacts with the Innovation Center and by exchange of ideas with other companies being started.

ECD manufactures and markets a precision autoranging digital capacitance meter and a digital thermometer. Its sales volume has passed the \$1 million level.

Mr. Eckhardt believes that expanded course offerings to include practical information on starting a business and on manufacturing technology are desirable.

Compu-Guard Security Systems Inc.
Pittsburgh, Pennsylvania

Dr. Romesh Wadhvani
President

Compu-Guard began operations at about the same time as the Center for Entrepreneurial Development at Carnegie-Mellon and, in 1975, had over \$1 million in sales. CED, according to Dr. Wadhvani, President of Compu-Guard, has played a very key role in their success. It provided services and guidance on business operations from the beginning and Dr. Baumann played a very critical role in the negotiation of their first contract. Later, a necessary injection of venture capital was obtained for Compu-Guard with the assistance of CED.

In Dr. Wadhvani's opinion, new ventures do not require much technological support. What is needed is the critical business advice that gives the new company the ability to survive in the marketplace its first year. This often takes the form of training the entrepreneur to make the necessary, difficult decisions that are required. Recommendations by Dr. Wadhvani focused on giving the centers greater flexibility, particularly in providing financing

and services for new ventures.

Medical Systems Laboratory
Carnegie-Mellon University
Pittsburgh, Pennsylvania

Professor Richard L. Longini
Director

An example of a developing project is an oximeter developed at Carnegie-Mellon. Dr. Richard Longini and several graduate students had developed this non-invasive optical method for continuous monitoring of the oxygen level in living tissue over a period of years and was interested in obtaining commercial development. The oximeter, using light backscattering, meets a persistent need of the medical profession.

A plan for commercialization of the device has been developed by a student team. Dr. Longini is complimentary of the process and of Dr. Baumann's guidance and advice. He believes that the Center is fulfilling a very much needed function of the university research community.

Beaverton, Oregon

Dr. Don Alanen
Manufacturers' Representative

Mr. Alanen has for many years interacted with inventors primarily by providing advice on manufacturing operations. He is a member of the venture team seeking to commercialize the therapeutic knee exerciser, an idea evaluated at the Oregon Center. The idea is for a device for strengthening knees after corrective surgery, and has had considerable development effort invested in it. The idea was evaluated favorably, studied at the Center, and is now being commercialized by a team, each member of which has invested in it.

In Mr. Alanen's opinion, the Oregon Center played a very critical role in creating credibility for the idea. The evaluation procedure and study results instilled the confidence in the inventors and investors that was necessary for further development. Considerable interest in the machine has developed among potential users and a local TV presentation on inventors will feature the knee

exerciser.

Strong support for the Oregon Center was expressed by Mr. Alanen. He will not hesitate to direct inventors to the Center and is aware of two inventions that can benefit from the evaluation process. His experience is that a direct approach to industry with an idea is usually unsuccessful; thus an inventor has nowhere to go with his ideas except the Center. Following the termination of the NSF experiment, Mr. Alanen believes that support should be provided by industry as well as State and Federal agencies to continue the Center as a needed public service.

Students

The entrepreneurs--particularly those who are successful--state that as students, they benefited greatly from the various entrepreneurial courses. In the absence of a student survey, the best overall measure of the success of academic offerings is the extent of student participation. In 1974, four hundred students participated, while in 1975, this number increased to 565, and in 1976, to 650. This trend is exhibited by all three of the participating universities and is, according to the Center Directors, expected to continue.

Venture Capital Firms

The viewpoint of a venture investment firm was reflected by Mr. Tyrone Dickerson, a Vice President of the Urban National Corporation in Boston. This investment company is funded by a number of other companies in an effort to channel capital into minority business operations. Mr. Dickerson was most familiar with the Center for Entrepreneurial Development at Carnegie-Mellon. He was very complimentary of the Innovation Centers Experiment and thought it was an excellent effort of the National Science Foundation. Urban National

has provided Compu-Guard with substantial capital. Without the essential support of CED, Mr. Dickinson was of the opinion that Compu-Guard could not have become an acceptable investment for his company. This investment is the only one in which Urban National was involved in a startup situation.

On the other hand, Dr. Richard Petritz, a partner in New Business Resources, a venture capital firm in Dallas, Texas, was unaware of the Innovation Centers Experiment, even though he had participated in a meeting on entrepreneurship at Carnegie-Mellon. As a successful venture capitalist, Dr. Petritz expressed interest in the "problem set" with which the experiment is dealing and referred to his associate, Mr. Richard Hanchen, who was closer to the venture capital area.

Mr. Hanchen, in a subsequent interview, noted that New Business Resources was one of only three firms in the United States that are involved in new start-ups, and that there have been no new ventures of a significant nature in the last three years. In his terms, venture involves the expectation of a minimum of 30 percent per year return on investment; and entrepreneurship, at a significant level, requires a commitment of capital in excess of \$5 million in order to be meaningful. He sees companies with revenues below several million dollars as having little possibilities for real growth.

Mr. Hanchen was totally unaware of the Innovation Centers Experiment and, when it was described, noted that it was no doubt good for creating jobs at a small scale and for educational purposes. However, if impacts are sought on broad national needs such as economic competitiveness, jobs, or capital investments, solutions must come from revisions in the tax and regulatory structure of government rather than from academic experiments. Results such as are being obtained relate to "proprietorships" and personal success, and will not attract

venture capital.

It was clear that success for ventures in the Innovation Centers Experiment, i.e., relatively small companies that make a reasonable profit, and are candidates for venture capital investments; and success for a venture capitalist where a return-on-investment of 30 to 50 percent per year is expected, represent two very different spheres. This difference, however, conforms to the educational objective of the experiment.

Industry

Industrial concerns are interested in the Innovation Centers Experiment as a source of product ideas and idea evaluation procedures, and as a service to which they can refer independent inventors. For ideas and products originating in the Innovation Center, an important avenue for commercialization is through adoption by industry. At the MIT Innovation Center, industry utilization is in the form of substantial industry support. Over \$100,000 in current support of specific innovation efforts was reported in May 1976. The outstanding product of this effort, to date, is an electronic game from which substantial royalties (in excess of \$15,000) have accrued. Since CED is not oriented to industry service, the contacts with industry reported here are limited to an assessment of the utilization of the Oregon Center's idea evaluation system.

RAY-O-VAC Division
ESB, Inc.
Madison, Wisconsin

Mr. Robert Zimmerman
New Product Manager

RAY-O-VAC is primarily interested in consumer products that are compatible with its marketing and distribution system. In contrast to many high technology industries that generate an excess of new product ideas, Mr. Zimmerman indicated that RAY-O-VAC is very receptive to new ideas from independent inventors. He

believes that there is a very definite role for university centers in identifying ideas for possible industry development. RAY-O-VAC has been interacting with the Oregon Center in evaluation of ideas that could result in new products. One such product has been carried to the test marketing phase, a thermocycler that redistributes room air to equilibrate temperatures. It did not obtain adequate consumer acceptance.

Mr. Zimmerman, in agreement with the Oregon Center, believes that there is still work to be accomplished in order to obtain an optimum idea evaluation system. He made two strong recommendations: (1) that at some early point in negotiations on an idea, the Center should draw back and allow the industrial concern and the inventor to interact directly in commercialization efforts; and (2) that the Center should not over-evaluate ideas. He felt that the industry could more accurately make judgments relative to producibility and marketability than could an academic group. In the evaluation process, he would like to have less methodology and a large catalog of ideas from which to shop.

Mr. Zimmerman, despite his criticisms, felt that the Oregon Center's idea evaluation system was the best he has seen--and he has tried other methods for obtaining new ideas. From his perspective, there are not enough ideas.

Technology Marketing Operation
General Electric Company
Schenectady, New York

Mr. Robert A. Roy
Technology Acquisition
Specialist

Mr. Roy is involved in the marketing of ideas. His sources of ideas are the diversified operations of General Electric (GE) which has more active patents than any other corporation in the world. Many viable product ideas are incompatible with GE's operations and, rather than let them die, an effort is made to identify alternative commercialization possibilities in either existing companies or by new ventures. Mr. Roy reports that these efforts are

paying for themselves.

On the basis of his broad knowledge of idea brokerage and the invention process, Mr. Roy believes that the Oregon idea evaluation system is fulfilling a very definite need of independent inventors. While inventors in large industries have plenty of support, independent inventors rarely know what to do with their ideas and are susceptible to profiteers. Mr. Roy believes that the idea of using a computer based objective analysis system is very good and that a creditable job is being done at Oregon. GE, as an example of a large high technology corporation, cannot be very receptive to outside ideas,* and thus cannot service the independent inventor. It can, however, refer them to the Oregon Center.

Mr. Roy noted that, in his opinion, the Oregon Center could never be self-supporting. A subsidy is required because independent inventors cannot pay the real cost of a creditable evaluation.

Academic Organizations

All of the Innovation Centers have attracted attention from other academic organizations that are operating or are interested in establishing academic entrepreneurial programs or are otherwise participating in the innovation processes. Awareness of the needs appears to be widespread and many universities are considering the various types of responses--business school programs, engineering school programs, interdisciplinary centers, or extension programs--that meet the needs. This type of utilization is a natural and expected

*Data are cited by Dr. Udell (G.G. Udell, "Unsolicited Product Ideas - A New Evaluation Program," Research Management, Vol. XIX, July 1976, p. 14), on an experiment wherein less than .01 percent of 30,000 solicited ideas represented original and meritorious technological thinking. This substantiates the theory that outside idea submissions produce little profit for corporations.

result of the experimental nature of the Innovation Centers Experiment.

Caruth Institute for
Owner Managed Business
Southern Methodist University
Dallas, Texas

Dr. John Welch
Director

Dr. Welch is an engineer by education, but an entrepreneur by experience. His organization is oriented toward helping people get started in business. Over 3,000 people have, in the last five years, gone to the Caruth Institute for assistance, and substantial ventures have resulted.

Dr. Welch, a graduate of MIT, noted that the environment in terms of resources, talent, and know-how of that institution, is extremely powerful for technical invention and creation of new businesses. However, for his type of operation, the Center for Entrepreneurial Development at CMU serves as a better model. Dr. Welch is faced with very practical problems that are not susceptible to textbook solutions or a structured response. The tailored response of CED to specific requirements of the entrepreneur, in his opinion, meets a much larger set of needs. The experiences obtained at CED are directly transferable to operations at the Caruth Institute and will continue to be of interest.

University of Washington
Seattle, Washington

Professor K. H. Vesper

Professor Vesper has conducted a study of academic courses in U.S. universities relating to the starting of new business ventures, i.e., the state-of-the-art in teaching entrepreneurship. In this activity, he has obtained excellent perspective on academic development of the field and notes its continuing expression, i.e., more courses, increasing numbers of students, more publications and the growth of special meetings. He noted that, in addition to the three centers associated with the NSF experiment, similar operations exist at Southern Methodist (the Caruth Institute), the University of Southern

California, the University of Pennsylvania (Wharton Business School), and the University of California-Pomona.

Professor Vesper's initial response to being queried on the Innovation Centers Experiment was that it was not an important part of the general academic activity in entrepreneurship and innovation. He felt that the focus to date had been such that research results were minimal, not many papers had resulted and, in general, dissemination was not very active. He attributed this to an emphasis on operations rather than research. However, on being informed of publications and other activities of the NSF supported effort, he noted that his comments were based on inadequate knowledge. Based on the information given to him, he recognized the significance of the Centers Experiment.

Professor Vesper recommended more support for research on entrepreneurship and innovation, particularly by doctoral students, so that the field might evolve, grow, and attract support.

Government Agencies

A variety of government agencies at the Federal, state and local levels are concerned with innovation and entrepreneurship. At the Federal level, the Energy Research and Development Administration (ERDA) is interested in the promotion of energy related inventions; the National Aeronautics and Space Administration (NASA) is concerned with the commercialization of their technology for non-space applications; the Department of Commerce has broad interests, including minority-owned businesses and economic development; the State Department is interested in transfer of entrepreneurial know-how to underdeveloped countries; the Department of Health, Education, and Welfare is interested in the educational facets of entrepreneurship and innovation; and other departments and agencies are defining participatory roles.

At the state level there is growing interest. It would not be surprising to find many states more vigorously extending efforts toward the encouragement of innovation and entrepreneurship.

Small Business Administration
Washington, D.C.

Mr. Henry Warren
Associate Administrator
for Management Assistance

Mr. Warren has a very broad perspective on productivity and entrepreneurial activities. He defines as a basic problem the stagnation of productivity in American business and industry, particularly small business and the service industry. The NSF Innovation Centers Experiment, in his opinion, is one part of a very broad, disaggregated effort. It is also his opinion that the experiment is successful from the standpoint of learning, but, if viewed as a strictly entrepreneurial effort, the economics are poor. Mr. Warren claims that the SBA, in its Small Business Institutes program, invests about \$125 to create a job and the Economic Development Administration (EDA) creates jobs for about \$170 in its similar efforts. In the NSF program, the costs are at least an order of magnitude greater. He admitted, however, that creation of jobs was not the prime objective of the NSF program. (It is also true that different measures are being employed and that simple comparisons are not valid.)

Mr. Warren, who was familiar with all three innovation centers, noted that while each was different, he thought each was worthwhile. The prime weakness of the experiment is that it is isolated from the many other related activities such as those of the SBA and EDA. The real payoff in terms of utilization, he feels, would come from a combined effort in which all of the necessary skills and activities are coordinated. His utilization of this experiment results from the demonstration of the operation of innovation centers in the academic environment--a mode which he espouses for the creation of many more centers with broadened skills and objectives.

Mississippi Marketing Council
State of Mississippi
Jackson, Mississippi

Mr. Gary Starkey
Marketing Specialist
Governor's Office

Mr. Starkey is concerned with applying the innovation center approach in Mississippi largely to encourage economic development. His knowledge is primarily about the idea evaluation system in Oregon and he is highly complimentary of that program. In fact, Mr. Starkey says that it is the best such program that he has seen. He is currently working with faculty of the state universities to attempt to emulate it in some form. Mr. Starkey volunteered 100 percent support of NSF in this program and expressed a wish that it could be continued and broadened.

Office of Energy Related Inventions
National Bureau of Standards
Germantown, Maryland

Mr. George Lewett
Director

Mr. Lewett expressed definite support for the Innovation Centers Experiment, noting that he gained most from the methodology being developed at the MIT Center. In fact, they are planning to send NBS evaluators to a forthcoming workshop being organized by Professor Li who has performed technical evaluations for them. The major concern of the Office of Energy Related Inventions is evaluating ideas for the Energy Research and Development Administration. Their evaluation system is not as structured as that being developed at the Oregon Center, therefore, they do not make extensive use of Dr. Udell's research. Mr. Lewett noted that Oregon was the origin of a disproportionately large number of ideas being evaluated in his office. This probably is stimulated by the Oregon Center.

Edmonds, Washington

Mr. Stan Sorensen
Independent Inventor

Mr. Sorensen has served on an ad hoc committee set up by the Department of Commerce of the State of Washington to consider invention encouragement.

Department officials were very impressed by the invention evaluation system in Oregon and Mr. Sorensen reports they have much respect for Dr. Udell. The committee proposed a similar operation be set up with state funding in Washington. The proposal was presented to a legislative committee of the State government. It was proposed that the Washington State Innovation Center would parallel Oregon's and would have close cooperation and interchange with Oregon. While the proposal was favorably received, it has not been funded and its eventual fate is problematical.

Mr. Sorensen is aware of inventors who have worked with the Oregon Center and reports that they are happy with the results they have obtained. He states, "I have carefully studied its concepts, goals and methods for over a year, and my opinion is that they are practical and worthwhile...If they (these sources) had been available in past years, I would have saved a small fortune, and would likely have proceeded with certain inventions which I dropped."

Others

A distinct class of individuals is that large group of private citizens who generate ideas in response to needs and problems that they perceive. All three of the innovation centers were originally intended to provide some form of support to such inventors, and they continue to do this. At MIT, however, little encouragement is given to the independent inventor; innovations are generated within the Institute in response to perceived and client identified needs. At Carnegie-Mellon, there is considerable service to independent inventors, but this is highly informal. The substantial effort is focused on a small number of ideas spawned in the University community. In contrast, the Oregon Center has as its major objective, the creation of a system that

is responsive to the needs of independent inventors.

Western Inventors Council
Eugene, Oregon

Mr. David Whitbread
President

Mr. Whitbread in one respect represents the community of independent inventors but, in another, is part of the program at the Oregon Center for Invention and Innovation. The conception and organization of the Oregon Center resulted from prior association of the Western Inventors Council (WIC, formerly the Oregon Inventors Council), with faculty of the University of Oregon. Since the beginning of the NSF supported Center at Oregon, submission of ideas has occurred primarily through WIC, and WIC participates in their evaluation. In addition, WIC serves as an advisory group for Center operations.

Mr. Whitbread believes that the idea evaluation system being developed by the Oregon Center is very good and is providing a valuable service to inventors. WIC, being the agent for the inventors, is in the best position to evaluate this and, in the course of development of the Center, was very much aware of the relatively large number of dissatisfied clients when the Center was started. The flexibility of NSF in its support of the Center and the competence of Dr. Udell were cited as valuable key factors in Center operations.

Eugene, Oregon

Mr. John Stewart
Patent Attorney

Mr. Stewart has referred clients to the Oregon Center and reports that they have been satisfied with the analyses and interactions that resulted. He will continue to refer clients to the Center because he feels that it fulfills a real need of independent inventors and is honest with them. A contrasting lack of confidence in commercial invention brokers was voiced by Mr. Stewart. He pointed out that ideas mature over long periods, therefore,

he cannot identify any commercial successes yet. Mr. Stewart believes that the public service provided by the Center warrants continued investment of public funds.

Features

There are a number of factors that appear to influence utilization of the Innovation Centers Experiment. An enumeration must include:

the experimental nature of the program--emphasis is on testing hypotheses on the education of entrepreneurs and on innovation, although in each center, this is interpreted differently.

the well-defined experiment duration--knowing that NSF support of the centers terminates in five years places emphasis on creation of future income and causes some to view the centers as transient perturbations in the educational structure.

the multi-objective structure--the hierarchy of objectives creates options in approaches and products and permits commendable program flexibility. At the same time, the measures of performance are not well defined and it becomes easier to "march to the sound of the drums" rather than follow a reasoned experiment protocol.

the caliber of the directors--through selection of strong Center Directors, a strong measure of enthusiasm, competence, and zeal permeates the centers and bodes well for their success.

the importance of the subject--innovation and entrepreneurship are in the national spotlight, thus the Innovation Centers Experiment benefits from a large receptive audience, but must bear the burden of detailed scrutiny.

the quality of the work--each of the centers can enumerate significant accomplishment and an apparent concordance of support from those served. The early victories have aided greatly in attracting recruits to the centers.

the resistance to change--as innovations in the education process countering established academic patterns, the centers meet with resistance just as does any interdisciplinary program in a disciplined structure.

the block funding--the initial commitment to full funding of the programs has been important in allowing the centers to obtain

institutional status and in avoiding the resource dissipation associated with renewal processes and the accompanying uncertainties.

the program management--although minor irritation was voiced relative to the documentation required for the experiment evaluation, no significant faults were attributed to NSF management in response to inquiries on this subject. All evidence points to an effective, flexible, and constructive approach to center supervision by NSF.

the liberal patent policy--the agreements permitting the centers to develop through patents and other means, income that supports present and future operations, are a significant factor in the experiment design and are apparently an innovation in government policy that could have far-reaching effects.

the nature of venture capital--in the business world, venture implies levels of risks and rewards that are beyond the resources of the Innovation Centers Experiment. Thus it appears that the ventures being undertaken must be considered as small-scale laboratory experiments, and recognition must be given in the research to the factors involved in full-scale ventures.

The sampling of ventures that received assistance from the Innovation Centers Experiment could be more voluminous and the response would not always be as supportive as the sample given. According to Dr. Udell, John Galloway in Eugene, Oregon, is not yet successful in his efforts to market a modular wine rack that he designed, although the Center for the Advancement of Invention and Innovation gave it high marks in their evaluation. An automated banana peeler developed at the Innovation Center at MIT has not been successfully exploited, evidently because the market is not as large as originally perceived. On the other hand, Computer Controls Corporation--for producing and marketing a building environment control system innovated at MIT, has just been started by Mr. Phil Doucet. A variety of other new ventures are in different stages of development.

In the first three years, 33 new ventures have been started with the assistance or direct involvement of the innovation centers. In 1975, sales were reported at \$2,700,000 and employees of these companies numbered about 200.

Conclusions

The Innovation Centers Experiment has funded three different types of operations--each of which, in its own way, is demonstrating the efficacy of innovation centers in an academic environment. The potpourri of results emanating from these centers is sufficiently diverse so as to have found much utilization, although as with many successful efforts, the boundary between participation and utilization is not well-defined. This success in obtaining utilization in no small measure stems from the fact that the experiment is funded at an adequate level and for an adequate duration; but other essential ingredients--management flexibility, dedicated Center Directors, competent participants, an enlightened patent policy, and early demonstrations of success--have also been important.

The ultimate utilization, e.g., permanence and replication of the centers and the success of the graduating students as innovators and entrepreneurs, can only be determined by collection and analysis of the relevant data. However, conditions appear favorable to such success.

Even though the success of ventures and innovations spawned by the Innovation Centers Experiment is noteworthy, there appears to be a tendency to overemphasize their importance relative to the experiment. The real objective must not be to create "proprietorships" or jobs (there are more efficient ways to do this) or even new inventions, but to learn how to train people and create an environment that leads to these things happening at a much faster pace in the real world.

In the way of recommendations, it appears that dissemination could be more

effective to some potential user types, more emphasis could be placed on the entrepreneurial/innovation processes in contrast to the present emphasis on commercialization successes, and more precision should be developed in the data being collected so as to insure its acceptance and credibility.

Mr. Colton points out that the bulk of the Center activities are geared to long-term measurements that will determine the effectiveness of the experiment. The apparent emphasis on short-range results is a pragmatic response to a short-range need to demonstrate that the Centers are productive at various levels, for many users, and on a continuing basis. Steps are currently being taken to refine and improve all aspects of the experiment.

Appendix A

Description and Organization of
the Individual Innovation Centers

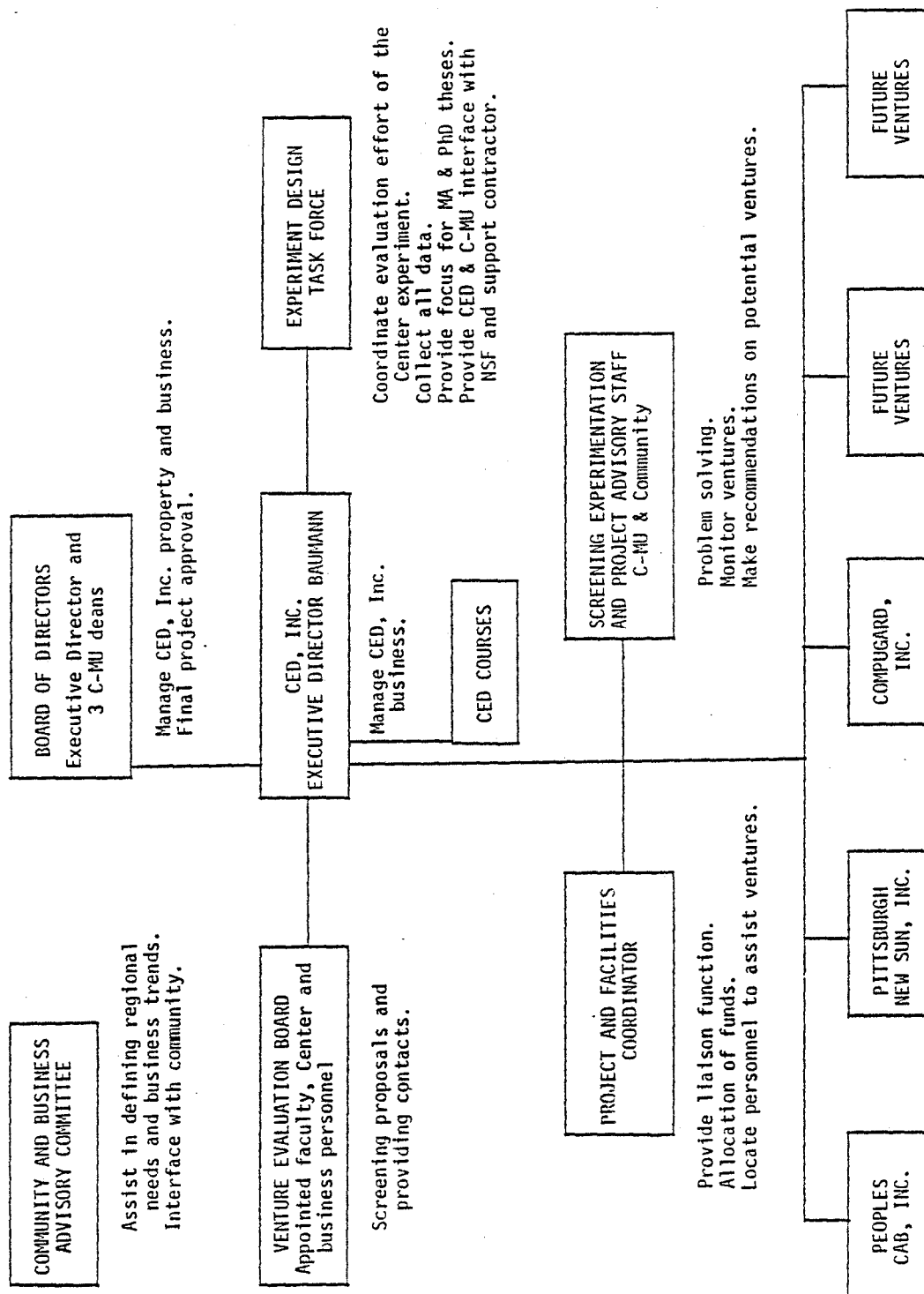


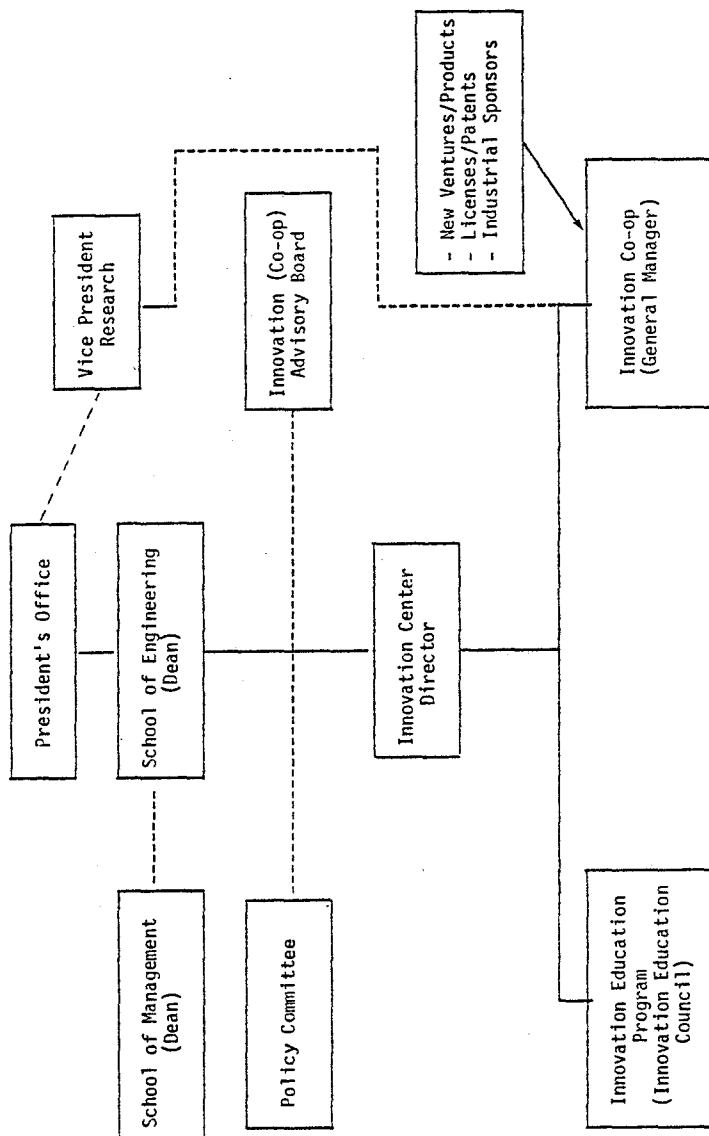
Figure A-1. Organization of the Center for Entrepreneurial Development, Inc.

Table A-1. Center for Entrepreneurial Development

Development of a Laboratory Experiment in
Technology Transfer Via Entrepreneurship

Carnegie-Mellon University

OBJECTIVE:	To encourage and develop entrepreneurial activities and innovation through education, research, and support of new ventures.		
STRUCTURE:	The Center is a separately chartered tax exempt corporation with the University as residual beneficiary. The Board of Directors consists of the Executive Director and three CMU deans. Three components of the University--Carnegie Institute of Technology, the Graduate School of Industrial Administration, and the School of Urban and Public Affairs, provide the academic base on which the Center was created.		
PROGRAM:	The Center provides courses in the engineering and management disciplines, including a Master of Engineering degree in design. However, its primary focus is on entrepreneurial activities. For these, it directly participates in the development of new businesses, arranges community service seminars, stimulates related academic activities, and is a resource center. It provides capital, where no commercial capital is available, and interfaces strongly with the small businesses that it spawns.		
ENROLLMENT:	1974	41 students	18 faculty
	1975	90 students	20 faculty
REVENUE:	Efforts are made to obtain venture capital for small businesses. No revenue to date.		
ACTIVITIES:	Three small businesses with 43 employees have been created. Others are in various development stages, and additional product ideas such as the oximeter are being considered.		
EXAMPLES OF PRODUCTS:	Small businesses: Compu-Guard, Inc., The Pittsburgh New Sun, People's Cab Company, International Lamp Corporation, and Bactex, Inc.		



Functions

- Plans, designs, and delivers the interdepartmental curriculum and basic innovation courses, and aids and encourages departments offering related courses and project laboratories.
- Provides supervision for established innovation projects and guidance and advice to students selecting projects for inclusion in the program.
- Performs ongoing research on the innovation process and entrepreneurship and disseminates research findings to the departments, outside organizations and other innovation centers.
- Evaluates the effectiveness of the educational program, including teaching methods, seminars and projects, and evaluates the overall educational effectiveness of the Center.

Functions

- Provide technical and marketing support to bring student-originated projects to maturity for commercialization.
- Provide the student with opportunities to participate in the entrepreneur activities of the co-op by participating in its decision-making process.
- Provide the student clinical experience in various technical and marketing activities relating to product development.
- Provide backup programs rendering the operation of the co-op economically viable.
- Provide review of legal aspects regarding inventions originating outside the Center.
- Documentation of the various activities of the Innovation Education Program.

Figure A-2. Organization of the MIT Innovation Center

Table A-2. MIT Innovation Center

A Supplemental Education System for the Training
of Innovators and Entrepreneurs

Massachusetts Institute of Technology

OBJECTIVE:	To encourage students with ideas to develop them into products with potential in the real market place and, thereby, to increase the supply and the quality of technical entrepreneurs through a supplementary education program. The Center is also conducting formal research on the innovation process.		
STRUCTURE:	The Center is organized as a division within the School of Engineering with support from the Sloan School of Management.		
PROGRAM:	Two programs are provided: 1. Innovation Education Program - An interdisciplinary program that provides two major parallel activities: (a) a set of elective courses; (b) a series of laboratory, workshop, office, and field activities relating to the generation of concepts, their subsequent evaluation and their development to a marketable stage. 2. Innovation Co-Op - An organization similar to a small R&D company wherein actual development and commercialization of inventions takes place. It provides a clinical environment in which students, with supervision and guidance, can undertake prototype development, experimental fabrication, patent application, market analysis, and promotion of new products, processes, and services.		
ENROLLMENT:	1974	58 students	18 faculty
	1975	150 students	23 faculty
REVENUE:	Royalties on innovations developed in center and industry project fees. (\$33,000 from outside sources in 1974.)		
ACTIVITIES:	As of May 1976, 23 Co-op projects were listed, 9 funded with project funds, 10 with industrial funds, and 4 were unfunded.		
EXAMPLES OF PRODUCTS:	Bicycle framesets, electronic games, current limiters, high efficiency bow, precious metal forgery detection system, small molecule detector, wide band electronic guitar.		

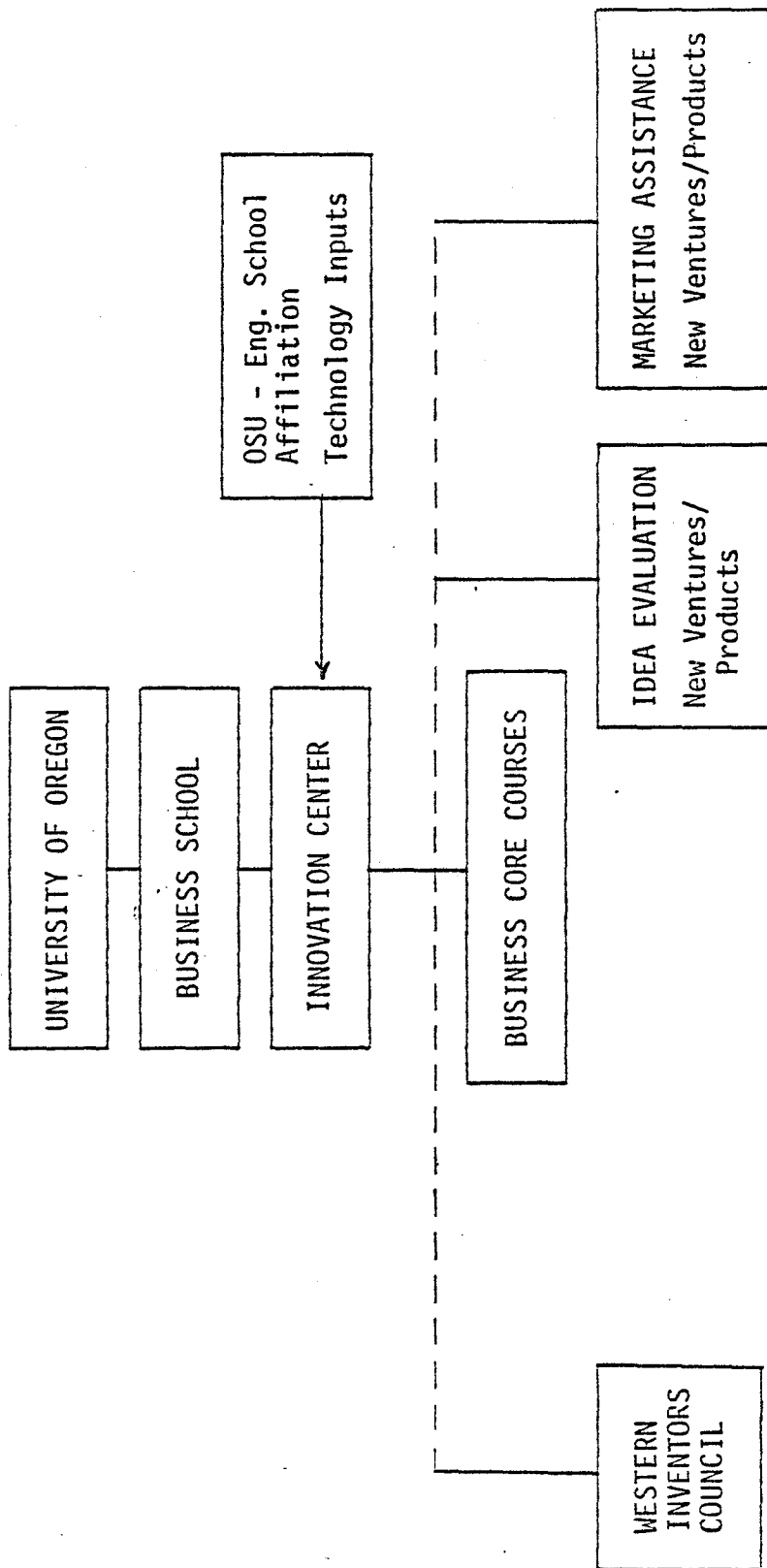


Figure A-3. Organization of the Oregon Innovation Center

Table A-3. Experimental Center for the Advancement of
Invention and Innovation

University of Oregon

OBJECTIVE:	To promote, encourage and stimulate technology transfer--specifically from the inventor to the innovator to society. The Center carries out education, public service, and research missions in support of this objective.		
STRUCTURE:	The Center is an entity within the College of Business Administration of the University of Oregon and is subject to normal University policies. The Western Inventors Council provides support to and participates in the Center programs. Liaisons have been established with other universities and with public and private installations, agencies, and firms.		
PROGRAM:	The Center identifies its thrusts in three distinct activity areas: education, public service, and research. In education, a curriculum of nine courses is offered covering the full spectrum of entrepreneurship and innovation. At present, the thrust of public service is the evaluation of a large number of inventions that are brought to the Center and the moving of worthy ideas to the marketplace. Finally, research is in two parts: the first relating to the Center and the invention evaluation process, and the second consisting of faculty conducted, Center funded research.		
ENROLLMENT:	1974	301 students	8 faculty
	1975	325 students	10 faculty
REVENUE:	Fee of \$25 required for each evaluation, but revenue is assigned to Western Inventors Council and is being accumulated in a trust. No revenue has yet been realized from the marketing of ideas and the NSF funding is the sole financial support for Center operations.		
ACTIVITIES:	A very large number of ideas has been received and over 500 have been evaluated. During the year ending June 30, 1975 alone, over 70 patents were issued on these ideas; and some 8 product efforts have been initiated.		
EXAMPLES OF PRODUCTS:	Plumbing fixture to allow setting of bath temperature, wood burning stove, three-wheeled car, wine rack.		

Appendix B

Product Experience of the Innovation
Center Experiment

Table B-1. INNOVATION CENTER CASES - 1974-76 (Provided by NSF)

CASE NUMBER	CENTER	MAJOR AREA OF INTEREST (2)	1974/76 PRODUCT	1974/76 COMPANY	1974/76 CENTER INVESTMENT	1974/76 (1) SALES	1974/76 CAPITALIZATION		1974/76 (1) EMPLOYEES
							LOANS	INVESTMENTS	
1M	MIT	III	Current limiting device	Semtel	\$ 0	\$ 1,000,000	\$ -	\$ -	40
2M	MIT	II	Bicycle framesets	Klein Corporation	13,000	1,200	20,000	2,800	2
3M	MIT	II/III	Electronic games	Interglobal, Ltd. (Kemtech, Inc.)	0	35,000,000	-	35,000	100 (3)
4M	MIT	II	Precious metal counter-detector	Iletra Corporation	0	500,000	-	20,000	5
5M	MIT	II	Wide band musical instrument	Three licenses	30,000	500,000	-	-	50
6M	MIT	II	Capacitance meter	ECD Corporation	0	1,000,000	11,000	10,000	20
7M	MIT	II	Compound bow	AMF Corp. (License)	0	-	-	20,000	--
8M	MIT	II	Pulse width amplifier	Koss Corp. (License)	0	-	-	27,000	--
1R	ORE	I	Wood burning stove	Fisher Stoves, Inc.	0	N/A	-	10,000	3
2R	ORE	I	Three wheel car	Transportation Concepts, Inc.	0	50,000	-	40,000	6
3R	ORE	I	Gold ore	Rare Ore, Inc.	0	2,000	-	500	6
4R	ORE	I	Nite transfer	Royal Industries	0	N/A	-	5,000	1
5R	ORE	I	Research and consulting services	MBA Consultants	0	4,500	-	-	15
6R	ORE	I	Tempa-bath	CCC Plumbing	0	N/A	-	7,500	--
7R	ORE	I	Cedar-mill wine rack	Redi-Grill	0	N/A	-	10,000	--
8R	ORE	I	Thermocycle	Thermocycle, Inc.	0	N/A	-	-	--
9R	ORE	I	Guyton table	SICO (License)	0	6,500,000 (5)	-	-	-- (4)
1C	CMU	III	Newspapers (printing technique)	Pittsburgh New Sun	1,000	95,000	-	2,000	9
2C	CMU	III	Transportation and related equipment (Computerized meters)	Peoples Cab Co.	0	200,000	92,000	18,000	35
3C	CMU	III	Blood diagnostic	Bactex Corp.	20,000	N/A	-	5,000	15
4C	CMU	III	Specialty computer hardware	Three Rivers Computer, Inc.	500	90,000	-	5,000	5
5C	CMU	III	Blood oximeter	Jessika Oximeter	40,000	N/A	-	4,000	3
6C	CMU	III	Security computer	Compu-Guard, Inc.	40,000	1,000,000	200,000	150,000	32
7C	CMU	III	Long life lighting	International Lamp Corporation	500	N/A	-	-	--
8C	CMU	III	Timesharing	Transcomm	0	500,000	-	102,000	14
9C	CMU	III	Prosthetics	Rehabilitation	35,000	N/A	-	-	2
10C	CMU	III	Remote control devices	Vectron	40,000	-	-	-	3
Totals -----					\$221,750	\$46,442,700	\$323,000	\$468,800	366

(1) Includes potential for 1976
 new and existing businesses
 (2) I - Invention evaluation and market development; II - Career training; III - Resource availability to
 (3) 400 additional employees at sub-contractor facilities
 (4) 100 additional employees at SICO facilities
 (5) Royalties - \$200,000 est. (\$65,000 guaranteed).



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 34

THE LESS CASH / LESS CHECK SOCIETY: AN IN-DEPTH TECHNOLOGY ASSESSMENT

ARTHUR D. LITTLE, INC.

Case Investigator:

J. N. Brown

Research Triangle Institute

P.O. Box 12194

Research Triangle Park

North Carolina 27709

Technical Reviewer:

W. P. Yohe

Department of Economics

Duke University

Durham, North Carolina 27706

Prepared under:

Contract No. NSF-C76-17165

National Science Foundation

Research Applied to National Needs

1800 G Street, N.W.

Washington, D.C. 20550

THE LESS CASH / LESS CHECK SOCIETY: AN IN-DEPTH TECHNOLOGY ASSESSMENT

Introduction and Summary

Technology for the most sophisticated electronic funds transfer systems exists today. Experiments involving applications of electronic funds transfer systems have been and are being tried throughout the United States. Segments of the depository financial industry see electronic funds transfer as a means of improving competitive positions and achieving economy. The Federal Government views electronic funds transfer systems as a means of achieving economy in making payments.

Trends toward introduction and wide-scale application of electronic funds transfer raise concerns over a variety of potential impacts on U.S. Society. Protection of the individual's privacy may be eroded. Major shifts in the competitive positions of different components of the financial industry, e.g., commercial banks or thrift institutions may result; this, in turn, can cause major imbalance in the relative financial strengths of these institutions. Equity in the offering of credit to various groups in society may be disrupted. Decrease of float (i.e., uncollected checks of commercial paper in transfer) due to increased velocity of money transfer can impact business practices and financial control for individuals, institutions, and government, and can force changes in monetary control policies and mechanisms.

In 1973, Arthur D. Little, Inc. was funded by NSF to perform an in-depth technology assessment of the introduction of electronic funds transfer systems

(EFTS). The objectives of this study were to identify the possible ways in which electronic funds transfer systems may be introduced in the U.S., the groups potentially affected by this technology, and the potential beneficial and deleterious impacts of the technology. Additionally, various policy options were to be identified and the impacts of these policies on the introduction of EFTS and on the first and higher-order effects of EFTS on different sectors of society were to be assessed.

The results of the Arthur D. Little study were directed to the needs of the Congress, the recently formed Electronic Funds Transfer Commission and other regulatory and policy-forming organizations; the financial and supporting industries; and to EFTS user organizations including Federal, state and local governments, consumer groups, and business in general.

Since the Final Report was published in February 1976, considerable use of the results of this technology assessment has occurred. Utilization has been enhanced by the timeliness of the research itself and of the final report. Involvement of representatives from all major impacted areas of society in the User Advisory Committee has enhanced utilization of the results. The experience, capabilities, and reputation of Arthur D. Little, Inc. and of the Principal Investigator, Martin L. Ernst, have positively affected utilization.

It has been suggested that utilization could be further enhanced by preparation and publication of a management summary of the final report, implementation of a series of workshops and seminars on electronic funds transfer, and preparation of audio-visual presentations directed to concerns of impacted groups. Additionally, it is the case investigator's conclusion that utilization can be enhanced by an increased understanding of technology assessment on the part of a significant factor of the large and diverse potential user community.

Funding details and project personnel are listed in table 34-1.

Research Description

This utilization case study concerns an in-depth technology assessment (TA) of the expanding application of electronic funds transfer systems (EFTS) in the United States. The assessment was performed by Arthur D. Little, Inc. (ADL) during the period September 1973 to June 1975. The final report, "The Consequences of Electronic Funds Transfer--A Technology Assessment of Movement Toward a Less Cash/Less Check Society," was released in February 1976. Following is a brief description of present U.S. payment systems and EFT systems being implemented.

Present payment systems in the United States involve about 250 billion transactions per year and cost roughly \$14 billion or one percent of the Gross National Product. These systems are dominated by the use of currency and checks, with credit cards assuming an increasingly significant role. Cash transactions are estimated at over 200 billion per year, representing over 80 percent of the total transactions, and costing roughly 1½ cents per transaction. The estimated 28 billion checks written in 1974, although only 18 percent of the total transactions, represented more than 90 percent of the value of all transactions that year. The transaction cost is about 18 cents per check. Credit card transactions are growing rapidly and numbered about 5 billion in 1973. The average value (obligation) of each transaction was approximately \$14 and the average cost exceeded 50 cents per transaction.

Generally, the present payment systems are adequate. However, there are shortcomings that include: increasing costs of and long-range concerns about viability of check systems; potential for theft in cash transactions; government

Table 34-1
PROJECT INFORMATION

Project Title "The Less Cash/Less Check Society--An In-Depth Technology Assessment:	Grant/Contract No. NSF C844 ERP-7302746
RANN Program Manager Joseph Coates G. Patrick Johnson (Current)	RANN Program Area Exploratory Research and Problem Assessment Sub-Area: Technology Assessment
Principal Investigator(s) Martin L. Ernst	Schedule Start: September 28, 1973 End: June 29, 1975
Institution Arthur D. Little, Inc. Cambridge, Massachusetts 02140	Funding NSF: \$221,966 Other:
<div style="display: flex; justify-content: space-between;"> <div> Contributors/Collaborators <u>Core Team:</u> Martin L. Ernst, Project Director Edwin B. Cox, Deputy Project Director Anton S. Morton Paul E. Giese Gary A. Marple </div> <div> <u>Principal Consultants:</u> Raymond A. Bauer Anthony G. Oettinger Blair C. Shick </div> </div>	
User Advisory Committee See Appendix A.	
Precursor Activities See Appendix B.	

payroll, social security, and welfare check production and distribution costs; and government concern over impact of float on monetary control.

A number of electronic funds transfer (EFT) experiments have and are being tried. Data are being generated to allow plans for an assessment of future trends and impacts. EFTS being tried and planned generally fall into one of the following broad categories:

- Pre-authorized payments - pre-authorization such as those involving deposit of individuals' salaries into banks or savings organizations electronically. Other possibilities included are transfers between accounts and payments for utility bills, home mortgage payments, etc. being made electronically for the individual.
- Automated tellers - generally this allows individuals to make deposits or receive cash at convenient locations for a large part of each day or on a 24-hour basis.
- Point-of-Sale Devices (i.e., "cash register" type systems) - these systems capture data related to transaction at the point of sale in stores and businesses and may be used to authorize and effect credit purchases, to verify and guarantee checks, or to make an immediate transfer from the individual's bank account to the business from which he has made a purchase.
- Other proposed systems include the use of push-button telephones connected to centralized computers to effect a number of different types of payments.

Actual EFT experiments and projects which have been initiated include, but are by no means limited to, the following:

- Atlanta Payments Project (1969 to 1974) - this project accumulated

findings and conclusions concerning "Automated Clearing House" (ACH) studies in the United States and generated new and useful empirical data on ACH operations in the Atlanta, Georgia area.

- Instant Transaction Project - Hempstead Bank of Long Island, New York (1971 to 1972) - 35 merchants and 1,000 customers participated in this point-of-sale study based on the most advanced technology available at that time.
- Automated banking experiment - First Federal Savings and Loan Association of Lincoln, Nebraska (1974 to present) - inexpensive remote service units were placed in two Hinky-Dinky stores providing 7-day, 90-hours-a-week deposit, withdrawal of cash, and other transfer and billing services. This experiment is particularly significant because commercial banks and other savings and loan associations initiated a series of legal battles culminating in a 1974 decision by the Comptroller of the Currency permitting national banks to establish "customer-bank communications terminals" without geographic restrictions. This ruling has since been changed several times and a number of court actions concerning its legality are underway.

Sufficient information and data have existed for a number of years to supply the impetus for a technology assessment of movement of our society toward wide dependence upon EFTS. This fact, coupled with our country's history of rapidly adopting new applications of technology, at least implies the possibility of widespread use of EFTS. Because of this possibility, a number of concerns over potential disbenefits within various sectors of our society have been voiced. Some of these are discussed in the following paragraphs.

The data networks which may be created between different financial

institutions and merchandising organizations and the tying together of credit and payments raise a series of questions. Privacy of an individual's financial records is an important issue. Prospective creditors need rapid access to financial records, but the possibility of unethical uses exists. Additionally, there is concern about the impact of these EFTS on equity in granting credit. Some of the considerations are: Are cash purchasers subsidizing credit purchasers? Are some credit purchasers subsidizing others? Is credit being offered equitably?

The introduction of EFTS into our payment systems can impact other areas of business--particularly the financial area. Commercial banks, savings and loan associations, mutual savings banks, and credit unions compete for both deposits and loans. The introduction of EFT by any one of these sectors can give that sector a rapid and significant competitive advantage over its competitors. This can in turn upset the balance of deposits among these institutions and, as a result, significantly unbalance the lending resources for mortgage loans, business and individual loans, etc. Such considerations have resulted in competition among these financial institutions for authorization to introduce new techniques. This has spread the competition from the institutions themselves to the various regulatory agencies providing authorizations for new facilities and services.

The above and many other considerations clearly establish the need for projecting the potential impacts of EFTS, the services they offer, and the manner in which they are introduced, on the operation of our financial institutions, on society in general, and on the government and business sectors of the United States. It is important to identify second and higher order impacts as well as direct effects in order that we understand all potential disbenefits and have this information available as decisions are made and policies are formed. The remainder of this section outlines ADL's specific objectives, the methodology

employed, and the products in its technology assessment of the introduction of EFTS.

The specific objectives of the EFT technology assessment as explained in ADL's final report were:

- "to investigate the consequences of movement toward an EFT-based society;
- "to determine who will be affected by this move, and in what way;
- "to analyze how the consequences and impacts will be changed or can be mitigated or extended, as a function of what path to EFT is followed; and
- "to propose means for monitoring what is going on and arenas for the resolution of issues as they arise."

It should be noted that ADL was not concerned with the design of EFTS, with recommending ways of marketing such systems, or with predicting precisely what will or should be in the future. Secondary objectives of the project were to continue the development of effective technology assessment methodology and to increase the total capability for performing technology assessments.

There is no universally accepted general methodology for conducting technology assessments; each must be conducted in the context of the technology involved, the state-of-the-art of the technology considered, and knowledge of the relevant social interrelationships involved, etc. The methodology applied by ADL in this technology assessment is an iterative one in which each phase consists of the following successive steps:

- specification of the status of EFT technology and the possible paths which may be followed in the move toward a less cash/less check society;

- identification of potential impacts and preparation of a matrix relating impacts to the relevant sectors of society; and
- analysis of the relationships between the potential technological scenarios which can be identified and the impact/societal sector matrix.

These three steps are taken in the first phase of the study based on literature reviews and existing knowledge within ADL and a series of interviews with cognizant participants. The subsequent iterations employ more in-depth and specific data sources, more extensive interviews, the generation of panel and survey data, and the application of more sophisticated analytical tools.

Utilization Objectives

The utilization objectives were to inform, to the extent possible (1) organizations involved in regulating and establishing policy for the introduction and use of EFT systems and (2) the impacted groups of the potential impacts of EFTS on all sectors of U.S. society and of the options available to optimize the benefits of and minimize the disbenefits of EFTS. The regulatory and policy-forming groups involved include the U.S. Congress, various banking and financial Congressional committees and subcommittees, the EFT Commission, the Federal Communications Commission, the U.S. Postal Service, and State regulatory agencies, etc. The potentially impacted groups are potential users of the EFTS assessment. The major impacted groups and the possible effects of EFT systems on them are listed in table 34-2.

Utilization Plan

The utilization plan involves primarily wide distribution of the final

TABLE 34-2. IMPACTED GROUPS

<u>IMPACTED GROUPS</u>	<u>POTENTIAL IMPACTS</u>
Depository Financial Industries	<p>Competitive positions of component industries shifted</p> <p>Expansion of services into new areas</p> <p>Industry structure disrupted</p> <p>Relative financial strengths of component industries shifted</p> <p>Passage of legislation to tend to maintain present industry structure and relative financial strengths</p> <p>Smaller financial industries forced into dependence on services from larger organizations</p> <p>More complete financial records and enhanced access thereto results in more sound credit decisions and in decreased bad check losses</p>
Business Community	<p>Increased direct deposit of employee paychecks</p> <p>Increase use of pre-authorization and automated banking in billing and payment operations by utilities, department stores, etc. resulting in decrease of float</p> <p>Creation of billing consolidation service organizations and business-to-business automated systems</p> <p>Increased standardization procedures and documentation</p> <p>Loss of control of financial operations by individual businesses</p>

TABLE 34-2. IMPACTED GROUPS (CONTINUED)

Individuals	<p>Carry less cash; experience increased physical security</p> <p>Individual savings resulting from EFTS economics</p> <p>"Technological" theft</p> <p>Decreased float resulting from "instantaneous" payment for purchases and services</p> <p>Loss of "proof of payment"; i.e., cancelled checks</p> <p>Invasion of privacy</p>
Government	<p>Savings in areas of check production and distribution</p> <p>Pressure for regulatory actions</p> <p>Overlap in jurisdictions of agencies; i.e., FCC, FTC and EFTC</p> <p>Decreased float increases effectiveness of FRS in monetary control</p> <p>Financial data can enhance economic planning</p> <p>Great reduction in volume of mail handled by U.S. Postal Service</p>

report published in February 1976. The National Science Foundation made an effort to distribute the report to individuals and organizations in every sector of the society discussed in the preceding paragraphs. Eight thousand copies of the report were sent to Congressmen concerned with the financial industry, communications, and consumer interests; financial industries, supporting industries and industry representatives; consumer interest groups; Federal and state regulatory organizations, etc. Also, 1,000 draft final reports were distributed approximately one year earlier to individuals for comments, and to those most concerned with results of the study. Additionally, the request rate for the report has been high. The Government Printing Office printed 1,500 copies in January 1976. These were sold by May 1976. An additional 5,000 were printed in May 1976. As of August 31, 1976, 2,527 copies of the second printing had been sold.

On February 17, 1976, an announcement was released by both NSF and ADL. This news release (see Appendix C) had been prepared by NSF and approved by both ADL and NSF prior to its release. NSF sent the release to local newspapers, publishers, associations, businesses, professional journals, Science Board members, foreign news media, freelance writers, governors and governors' science advisors, state legislators, other state officers, and U.S. Representatives and Senators. As a result, items appeared in the New York Times (see Appendix C) and a number of other national and local newspapers. Additionally, the NSF Project Manager, Patrick Johnson, was contacted by the American Broadcasting Company to arrange a national interview with the Principal Investigator, Martin Ernst, which was aired on national ABC radio news on Sunday, February 22, 1976.

An article on the ADL study, "Looking Ahead: The Consequences of a Society with Less Cash/Less Checks," appeared in Mosiac, Vol. 7, No. 1, January/February 1976.

Individuals at ADL have published articles on the results of the technology assessment and have made a number of presentations at national conferences. The Principal Investigator, Mr. Martin Ernst, has testified before a number of Congressional subcommittees, including the Senate Banking Committee, on the subject of electronic funds transfer systems.

Finally, the User Advisory Committee, composed of representatives of the various impacted sectors, was utilized as a means for getting the final report to individuals having an interest in EFT.

Utilization Obtained

The primary objective of this utilization case study is to obtain an estimate of the utilization of the results of the EFT technology assessment. This estimate has been made by contacting potential users of the results. Potential users were identified through discussions with the program manager at NSF, the Principal Investigator, and final report distribution list obtained from NSF. The following paragraphs summarize comments made by the 17 individuals who were contacted in this case study.

The most used item in ADL's final report is the results of the data collected during the effort rather than the conclusion. Of 17 individuals contacted, practically all stated that it resulted in an impressive and useful resource on EFTS. Mr. Jim Howard, General Council, Electronic Funds Transfer Commission, referred to the ADL final report as "a compendium, an index of concerns, and a checklist on all aspects of EFT systems." Other references to the report includes: "a good source of general background information," "as good a reference as exists today," and "an important work giving useful and needed information." Mr. John B. Benton of the Electronic Funds Transfer

Commission indicated that the report was distributed to all 26 members of the Commission in February and that it was considered "must" reading.

Of the 17 individuals contacted, only two reported that they had not read the report. Mr. Ralph Rohner, staff member, Senate Banking Committee, had not received a copy of the report. Mr. Peter Shuck, Consumers Union Advocate Office, had not received a final report.

Mr. William McManus, Executive Vice-President, Envelope Manufacturers Association, reported that the ADL final report has been sent to all Association members. He stated that the study and final report were helpful to the Association in estimating the impact of EFT on the demand for envelopes.

Eight of the 17 potential users contacted reported specific instances in which the ADL report was directly used. Mr. S. Lees Booth, National Consumer Finance Association, reported that the ADL final report had been used in the preparation of an Association statement on Regulation J of the Federal Reserve Board which relates to EFT. He also indicated that the ADL study had contributed significantly to a report prepared by the Association on the financial industry and electronic funds transfer systems. Finally, he stated that Dr. Mark Bender of the Association has written a book on electronic funds transfer entitled, Electronic Funds Transfer Systems--Elements and Impacts, to be published in the near future. Dr. Bender has made considerable use of the ADL study in his book.

Mr. James Kudlinski, a director of the Federal Reserve Bank operation's Board of Governors of the Federal Reserve System, uses the ADL report frequently in responding to inquiries directed to the Federal Reserve System.

It was learned from Mr. Bill Weber, Senate Banking Committee, that in 1975, the Senate Banking Committee had used a draft report from ADL to propose legislation to create a new framework for the introduction of EFTS. Specifically,

this legislation would have made it possible to establish automatic banking facilities without their being categorized as branch banks. The proposed legislation was not successful at that time.

The Department of the Navy is presently planning to utilize electronic funds transfer technology for deposit of employee paychecks. (The Air Force is already using EFTS for this purpose.) Mr. William Blumberg, Financial Systems Department, Navy Accounting and Finance Center, is involved in the planning process and he reports that the ADL report has been of significant value to him in this work. He has made use of information on the state-of-the-art of EFTS, regulatory aspects of EFT, paper workloads in government and the banking sectors, privacy aspects of EFT payments, and possible employee resistance to the introduction of EFT by the Navy.

The Wells Fargo Bank in San Francisco is utilizing information on present check processing, on consumer demands for EFT services, and a number of scenarios of future EFTS implementations contained in the ADL final report in studying EFTS marketing services that the bank will be involved in through 1980. Mr. William Ford, who is in charge of planning at Wells Fargo Bank, reported that the ADL report has supplied a frame of reference for these planning activities. He is concerned with the general protection of customers--particularly their privacy--and how his organization should interface with consumer groups.

Mr. John Brown, Public Interest Research Group, indicated that he has utilized data and information resulting from the EFT technology assessment to prepare a number of presentations to trade association groups and mutual savings bank groups. His principal concerns are privacy and consumer affairs.

The U.S. Postal Service has established a task force on EFTS to plan for the introduction of electronic funds transfer systems. Mr. Vandergrift of the Postal Service reported that copies of the ADL report had been sent to all

members of the task force. He indicated that the ADL study was most timely and of significant value to the Postal Service and would find continuing use. Most important in his opinion was information on the potential impact on the Postal Service and data on volume of checks expected to be mailed in the future. He indicated that more cost data would be of value. Finally, he indicated that a copy of the report had been sent to an econometrician in the Postal Service who was studying future volumes of mail.

Mr. Kenneth Reich of the U.S. League of Savings Associations indicated that he had not yet distributed nor announced the release of the Arthur D. Little report because his first reaction was that the report was not appropriate for use by individual savings and loan associations. Based upon his second thoughts, he indicated that he would now announce the report to savings and loan association representatives. This increased distribution of the report can begin to stimulate more studies of EFT within savings and loan associations and significantly increase utilization in this sector. He recommended that utilization could be enhanced by the preparation of a management summary report, the availability of an audio-visual presentation on EFTS, and a series of workshops and seminars.

A few of the individuals contacted indicated that (1) the final report was published too late to be of value and (2) the data in the report was and had been available in other sources. The ADL study was an effort to identify alternate futures with respect to the introduction of EFTS, and identify and assess policy options with respect to their effect on all impacted sectors of society. The study was not an effort to generate any new data on EFTS. Those individuals who are familiar with all existing sources of EFTS data, who are keeping new EFT data and are not concerned with questions of a policy nature must be disappointed with the ADL final report. These same individuals will

also correctly observe that the data published in the ADL report were available earlier in other sources. Comments of the nature considered here are reported in the following paragraphs.

Mr. S. Lees Booth of the National Consumer Finance Association indicated that delays in publication of ADL's final report had, in his opinion, limited the usefulness of that document because of rapid developments in the EFT field. He also stated that distribution of the report had been inadequate, but was not specific on this point. Mr. McMannus, Envelope Manufacturers Association, also indicated that the report was long and difficult to read. Mr. Allan Lipis, who was Director of the Atlanta Payment's Project and is now with Payment Systems, Inc., stated that EFT is a very important area for investigation and study. He recommended that NSF fund a number of other and more comprehensive studies. The most important need at present, in his opinion, is a nationwide economic study of electronic banking; and while the ADL Project consolidated a great deal of useful information, none of the work was original. He stated that Payment Systems, Inc. had the information, and that much of the information published in the ADL final report was four to five years old.

Professor Dwight M. Jaffee, Department of Economics, Princeton University, stated that he was disappointed in the ADL study because it added nothing to existing data on the introduction of EFTS. He stated that information in the ADL final report was published in 1973 in his book, Economic Implications of an Electronic Monetary Transfer System. Ms. Heida Kargman of Cornel University, who is investigating the EFT aspect of an NSF-funded technology assessment of telecommunications, reports that the ADL study was of "no use." She indicated that while the final report was an impressive collection of data, their research group needed the information one year earlier and that they had to

collect the data they needed. Ms. Helen Nelson of the University of Wisconsin at Milwaukee indicated that the final report was only moderately useful in relation to her studies of consumer needs.

Other specific uses of this project were cited by the Principal Investigator, Mr. Martin Ernst of Arthur D. Little, Inc. He indicated that a number of projects at ADL had been initiated as a result of their EFT technology assessment. For example, the Bankers EFT Handbook has been prepared by ADL with funding from the American Bankers Association.

Considering that the final report on this project was released in February of this year, the general response of individuals from a variety of different organizations and the number of specific uses of that final report are impressive. There are indications that utilization is in its early stages and that the greatest impact of the work will occur in the next one or two years.

Mr. Ralph Rohner, a staff member of the Senate Banking Committee, indicated that the Committee will very likely make significant use of the ADL project and the information collected in that activity. He stated that the Senate Banking Committee will begin to formulate and propose legislation in the EFT area following the report of the EFT Commission which will be submitted to Congress late in 1977. Additionally, it is expected that the EFT Commission, which was established within days after the release of the ADL final report, will make continuing and quite significant use of that body of information.

Features

The success of this technology assessment, as with any research project, depends to a large extent upon the experience and capabilities of the organization performing the work and the Principal Investigator who coordinates and guides the various phases of the project. Mr. Ernst's considerable experience

in working on and coordinating the efforts of multi-disciplinary teams has been a significant factor in the coordination of this project. As Principal Investigator, he was the bridge between the physical and social scientists who participated. He indicated that he made certain that the physical scientists initiated and completed the bulk of their work in developing the required data base before he brought in the social scientists.

Successful technology assessments must involve both an industry based organization and academic groups. Arthur D. Little, Inc. has considerable experience in working with industry and in collaborating with academic groups.

The user group to which this technology assessment is directed is broad. It ranges from the banking sector, to minority groups, to suppliers of materials and services. The banking industry itself is fragmented, structurally and geographically. It consists of both small and large corporations having different market sectors and capabilities for supplying different levels of service and technology. Successful implementation of EFTS with an optimum mix of impacts on all sectors will require a cooperative effort from financial and supporting industries, regulatory and policy setting bodies, and consumer groups. Industry competition and jurisdictional overlaps within government regulatory bodies create barriers to an effective and integrated approach to the introduction of EFT for maximum benefit to society in general. The creation of the Commission on Electronic Funds Transfer is a step toward the removal of many of these barriers by the establishment of a single agency which can influence both policy and regulation.

Individual consumers, consumer advocate groups, labor representatives, and minority group representatives in many cases do not have the resources and structures to affect the manner in which EFTS will be introduced. The ADL report and its distribution attempts to expose these sectors of society

to information relevant to their needs so that they can have some impact on the introduction of EFT.

The utilization plan involved in this effort was primarily an effort to achieve wide distribution and exposure of the report and the results it contains. These efforts consisted of articles in the national news media and wide distribution of the final report itself. Several presentations at EFT related conferences and a number of articles on EFT have been published. Finally, testimonies have been made before Congressional subcommittees.

In general, the EFT technology assessment was performed at the appropriate point in time. The technical data base required for this study was available; EFT system experiments were being performed; and concerns over the possible impacts of EFT were coming from several sectors of society. The release of the final report was most timely from the standpoint of the establishment of the National Commission on EFT. This timing was appropriate also for other policy, regulatory and legislative bodies.

Conclusions

The ADL final report on Electronic Funds Transfer Systems is being read and studied by members of regulatory and policy setting bodies and by members and representatives of those sectors of society which may be impacted by the application of EFT systems. The variety of uses identified in this case study include the following:

- Input to planning functions--this activity was identified in the depository financial sector and within the Federal government.
- Input to preparation of proposed legislation--the Senate Banking Committee has made use of the EFT technology assessment in this

manner and indicates that it will do more of this in the future.

- Input to the preparation of proposed regulations at the federal level--the Electronic Funds Commission is using the ADL report to a significant extent in this activity.
- Input to statements of and clarification of policy--the Federal Reserve System is utilizing the ADL final report in responding to inquiries.
- Guide to understanding the possible developing applications of electronic funds transfer and the possible impacts of these developments on various sectors of society. Individuals and groups in various sectors of society are utilizing the project results in this manner. This seems to be particularly significant in the areas of consumer protection and the delivery of financial services.

In light of the short time that the final report on ADL's project has been available--approximately five months--utilization of the information available has been significant. It is expected that utilization of the work results will increase in scope and in significance over the next one- to two-year period.

Appendix A

USER ADVISORY COMMITTEES

OVERSIGHT COMMITTEE (User Advisory Committee)

S. Lees Booth
National Consumer Finance

Berkeley Burrell
National Business League

William Ford
American Bankers Association

Bickford Henche
National Association of
Mutual Savings Banks

Peter Livingston
Credit Union National Assoc. Inc.

Peter McCloskey
Computer & Business Equipment
Manufacturers Association

Carl Nelson
Financial Executives Institute

Helen Nelson
Center for Consumer Affairs
University of Wisconsin

Kenneth Reich
U.S. League of Savings Assoc.

Clifford R. Schuman
National Retail Merchants Assoc.

Lazar Teper
International Ladies Garment Workers Union

FEDERAL ADVISORY COMMITTEE

Donald Baker
Department of Justice

Paul Horvitz
Federal Deposit Insurance Corp.

James Kudlinski
Board of Governors of the
Federal Reserve System

Lloyd Morgan
Department of the Treasury

David Motter
Office of the Comptroller of
the Currency

George Oram
Federal Home Loan Bank Board

Carroll Smith
National Credit Union
Administration



Appendix B

PRECURSOR ACTIVITIES

Arthur D. Little, Inc. has prepared a number of studies related to various aspects of EFTS. Examples of these studies are as follows:

ADL has developed projections of demand for banking services and technology available for meeting the demand by the end of the decade.

ADL investigated the ability of the nation's check collection system to handle the volume of checks written during the 1970's for the American Bankers Association.

A multi-phase study of the credit card industry performed for a regional association of Master Charge banks.

ADL performed a study directed at creating a detailed profile of the attitudes, expectations, and preferences of association members of the inter-bank card association. ADL overall study of credit operations for major oil company.

ADL provided a system to prevent the misuse of credit cards to a credit card manufacturer.

ADL provided information and recommendations on the marketing of an automatic teller system for a manufacturer of bank automation equipment.

ADL has assisted in evaluating market opportunities for certain propitiatory technologies applicable to point-of-sale systems.

Appendix C

NSF NEWS RELEASE

Ralph Kazarian
(202) 632-5728
Home: (703) 451-0681

FOR RELEASE:

February 17, 1976
NSF PR76-17

ELECTRONIC FUNDS TRANSFER

SEEN HAVING IMPACT

ON WHITE COLLAR WORKERS

Increased use of electronic funds transfer (EFT) will not make cash or checks obsolete, but will have an impact on white collar workers, according to a report released today by the National Science Foundation (NSF) and Arthur D. Little Inc., a Cambridge, Massachusetts, research firm.

Besides white collar "automation", EFT will have an impact on the "information revolution" because of the "ease and economy with which large amounts of data can be collected, aggregated, manipulated and distributed," the report said.

EFT is an application of technology that could lead eventually to a condition in which payments, now dominated by cash and checks, might be largely replaced by systems based on electronic signals and records instead of paper.

EDITORS: A simultaneous release is being made by Arthur D. Little Inc.

-more-



1800 G STREET • WASHINGTON, D. C. 20550

34-27

Significant changes in the financial industry and the regulatory system under which it operates are probable with use of EFT technology. This should have some impact on the life styles of individuals, the report said.

The report is titled "The Consequences of Electronic Funds Transfer: A Technology Assessment of Movement Toward a Less Cash/Less Check Society."

Funded by the NSF's Research Applied to National Needs (RANN) Program and prepared by ADL, the report deals with the possible consequences of the introduction and spread of EFT systems. The overall objective was to investigate the consequences of movement toward an EFT-based society. An analysis was carried out to determine how the consequences and impact can be changed or mitigated depending upon which path to EFT is chosen. The study proposes means for monitoring EFT activities and suggests institutions for the resolution of issues as they arise.

The President has appointed a National Commission on Electronic Funds Transfer to study the entire question of EFT and recommend appropriate administrative action or legislation. An interim report of that group is due in October.

Besides assessing the impacts on the financial industry, the ADL team investigated the possible effects of EFT on business in general, the government, and individuals. The impact of EFT on personal privacy, freedom of choice, crime, consumer behavior, and methods of information handling are described in the 238-page report.

Business will feel the impacts of EFT in a variety of ways because of its activities as an employer, as a sender of bills and receiver of payments, and in the conduct of financial transactions associated with purchasing, distributing and selling goods and providing services, the report said.

Government will feel the impacts of EFT primarily through its function as an originator of payments and as a regulator of financial transactions.

Individuals, the report said, are generally satisfied with the current payments system.

"As a result," it said, "they will move slowly in accepting EFT, except where it meets specific needs and does not appear to pose a threat. Individuals will take advantage of the increased physical security that results from carrying less cash and have already demonstrated a willingness to take advantage of the convenience EFT can offer.

"Acceptance will be speeded if the costs for conducting financial transactions are made more explicit.....and if it is made clear that individuals are sharing the economies EFT makes possible."

EFT will affect the life styles of some persons, according to the report.

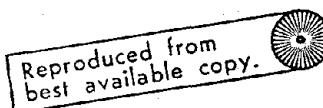
"The family authority structure may be altered by what amounts to a decrease in parental control, as younger members seek access to debit and credit cards, which delay parental knowledge of how much has been spent on what. Some special protective mechanisms may be necessary to prevent family financial resources from being misused by juvenile card users."

In a section headed "Key Elements in EFT Introduction", the report said: "When the variety of potential impacts are examined, it becomes apparent that a large fraction of them can be strongly influenced by steps taken in three important areas: (1) maintenance of choice for individuals and businesses in their use of different media and services; (2) control of certain sources of possible misuse of EFT; and (3) alleviation of some of the stresses concerned with the displacement of old methods of payment and the introduction of new ones."

Control over potential misuses, the report said, entails the assurance of a reasonable level of fraud protection, responsive error-correction mechanisms, and secure access identification techniques and procedures. Protection of privacy standards and avoidance of misuse of data collected as part of a system's operations are equally important, the report continued.

The report pointed out that after a decade of discussion, planning and controversy, many elements of EFT technology are finding their way into society's daily work and business habits. This has not come about because of dissatisfaction with the current payment system, or unreasonably high costs. It arises, the report said, mainly from the fact that technology has opened up a range of possibilities for activities that market leaders have recognized and seek to exploit.

"In part through its own potential and in part through its catalytic effects, the long-term influences of EFT on our society can be enormous," the report said. "It can, for example, create an entirely new environment for conducting many basic financial transactions.....In creating a new environment, EFT can stimulate changes in our social institutions and relationships."



-END-

Note: Single copies of the report may be obtained by writing to the NSF/RANN Document Center, Room 1241, 1800 G Street, N.W., Washington, D. C. 20550.



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 35

URBAN TECHNOLOGY SYSTEM

PUBLIC TECHNOLOGY INCORPORATED

Case Investigator:

J. N. Brown

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

O. White

Department of Political Science
University of North Carolina
Chapel Hill, North Carolina 27514

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

35-2

URBAN TECHNOLOGY SYSTEM

Introduction and Summary

The experimental Urban Technology System (UTS) was formerly funded by the National Science Foundation (NSF) through the Experimental Research and Development Incentives Program (RDI) of Research Applied to National Needs (RANN), but is now funded and managed through the Intergovernmental Program of RANN. UTS is one of three experiments designed to test the effectiveness of federal incentives in stimulating the utilization of technology by local governments. The other two are: "Program for Increasing Use of Technology in Local Governments" and "Stimulating Technology Applications and Utilizations in Smaller Units of Local Government." UTS was conceived, implemented, and is managed by Public Technology, Inc. (PTI), a non-profit research and development corporation. Project information is given in table 35-1. Following is a summary of the UTS program, its objectives, and its accomplishments.

Governments are faced with ever increasing demands for services, continuously increasing costs of delivering those services, and failure of revenues to keep pace with rising costs. Local government managers need technology to provide more efficient and productive methods to meet this cost/revenue squeeze. The UTS program is designed to assist local governments in coping with such a squeeze.

The UTS is composed of 27 participating local government units (cities and counties) or "test sites"; 15 technical "backup sites" (universities, research institutes, and private firms); and a coordinating, management body (PTI).

Table 35-1
PROJECT INFORMATION

Project Title URBAN TECHNOLOGY SYSTEM	Grant/Contract No. C834
RANN Program Manager Evan Anderson Elisha C. Freedman Thomas P. Anderson	RANN Program Area Experimental Research and Development Incentives Program
Principal Investigator(s) Ronald J. Philips Program Director James L. Mercer Stanley R. Goldberg (Current)	Schedule Start: July 1, 1973 End: Nov. 30, 1977
Institution Public Technology, Inc. 1140 Connecticut Avenue, N.W. Washington, D.C. 20036	Funding NSF: \$4,355,930 Other: \$3,837,200
Contributors/Collaborators SEE APPENDIX A	
User Advisory Committee SEE APPENDIX B	
Precursor Activities 1. Public Sector Technology Innovation Process, Contract NSF-C753, December 1972. 2. Methodology Study of an Urban Technology System, Contract NSF-C791, July 1973.	

A technically or scientifically trained Technology Agent (TA) is placed in the office of the chief administrator in each city or county test site. The TA identifies requirements for technology which can reduce costs of, or increase productivity in, the delivery of local government services. He meets these requirements through identification of applicable technology through his own knowledge or by the backup sites, other TAs or PTI. The links between the TAs and backup sites form a network for rapid and comprehensive communications on requirements and innovations in participating local governments. This is expected to lead to the aggregation of requirements within local governments, to more rapid diffusion of innovations, and to the generation of valuable information on the innovation process in local government units.

When the UTS program is completed, the products of the experiment are expected to be:

- Increased technological innovation in the 27 test sites;
- Stimulation of private investment in R&D directed to solving problems in local governments and resulting from market aggregation efforts;
- Acceleration of the diffusion of innovations among the test sites;
- Assistance to the Federal government in setting R&D priorities; and
- Information on the innovation process in the non-Federal public sector.

With the operational phase of the program approximately 60 percent complete, there is considerable evidence of increased technological innovation in most of the 27 test sites. This evidence consists of 95 examples of technologies* being applied to solve specific problems in the test sites. This case study addresses primarily the utilization of these examples of technological

*The term technology will be understood to include devices, tools, systems processes, and operational methods and procedures.

innovation. An assessment of the utilization of the other products of this program can be made when the experiment is completed. However, it has been determined that as of July 1, 1976, all 27 of the original test site cities are paying 80 percent of the technology agents' salaries and 100 percent of the associated fringe benefit and overhead costs.

An investigation of a subset selected at random from the 95 technological innovations which have been reported by PTI indicates that utilization of the technologies involved is occurring and that significant benefits to the test site local governments have been realized. Additionally, data sampled by PTI indicate that the potential annual cost savings and cost avoidance resulting from these technological innovations exceed the cost of the UTS experiment.

Research Description

In March 1972, the Executive Office of the President assigned to NSF a leading role in developing new programs to determine effective ways of stimulating non-Federal investment in R&D and of increasing the applications of research and development efforts. This was to involve experiments to investigate partnerships between various levels of government, private firms, and universities. New arrangements for cost-sharing, patent licensing and research support and incentives testing were to be investigated.

Working with potential users of technology in state and local governments, NSF developed guidelines for its Experimental R&D Incentives Program in the public service sector in June 1972. This program was to focus on public institutions (i.e., governments) with emphasis on experiments designed around incentives for overcoming barriers to innovation. The RDI Program is based on the fundamental assumption that many of the problems faced by state and local

governments are related to science and technology; i.e., that by the application of science and technology, costs of providing services may be reduced and productivity increased.

In July 1972, PTI held a symposium in San Francisco with representatives from PTI, NSF and industry to investigate barriers to technology innovation in the public sector. It was found that industry views the local government marketplace as highly disaggregated and a difficult system in which to work. The major difficulties identified were the lack of:

- Clearly stated user requirements for new products and processes; and
- Technical manpower capability in the staff and line operations of local government.

In August 1972, PTI held a symposium in Denver attended by NSF representatives and local government officials. The most frequently voiced barrier to innovation was lack of adequate technical manpower in local governments. Additionally, the need for more R&D funds for satisfying the critical needs of local governments was generally cited. Finally, improved information exchange between local governments was determined to be an important need.

With funding from NSF/RANN, PTI undertook a comprehensive, five-month study of barriers to, and incentives for, innovation in local governments. This study led to the concept for and design of the Urban Technology System which is the framework of an experimented program to test the effectiveness of a specific approach to stimulating innovation in the public sector and for overcoming the aforementioned barriers to technology utilization and innovation in local governments. The emphasis in the UTS is on the innovation process in general and includes both identification of new technology applications and diffusion.

The primary objectives of the experimental UTS program are to determine the following:

- The effectiveness of the institutional alignment of technology agents, R&D institutions, and a user representative system manager in increasing the amount of technological innovation in a 27-test site network;
- Whether such a system can exert a market aggregation force that will stimulate private investment in R&D directed toward the non-Federal public sector;
- Whether the system can result in an accelerated diffusion of innovations among the test sites;
- Whether a representative and technically supportive network of local government units can be a useful mechanism for assisting the Federal government in setting R&D priorities; and
- Whether the data collected from the experiment can provide more information on how innovation takes place in the non-Federal public sector.

The three components of the UTS are: The System Manager, the Technology Agents (TA), and the Technical Backup Sites (BUS). PTI manages the System and has primary responsibility for:

- Establishment of the system;
- Development of a technology agenda for UTS test sites;
- Capital formation activities for problems common to a number of test sites;
- Direction of market aggregation activities;
- Direction of, and responsibility for, data gathering operations and documenting performance of the UTS;

- Conducting regional and national meetings of the participants of the system; and
- Aiding diffusion of technology among the test sites.

The key to the UTS is the Technology Agent who is an engineer or scientist working in the office of the chief administrative officer of a local government unit. TAs have been placed in 27 cities and counties having populations ranging from 50,000 to 500,000 and located throughout the United States (see Appendix A for locations of TAs). The major functions of the TA are to provide technical capability within the chief administrator's office, and to link the city government with a system of organizations having technological expertise in areas of importance to local governments. The duties of the TA are to:

- Act as a catalyst for the infusion of technology into the test site;
- Act as a task force leader in the solution of specific problems;
- Be a "point of entry" for technological information into his test site (including the experience of other test sites); and
- Represent the test site in market aggregation activities.

The 27 TAs are supported technically by 15 "backup sites," by the UTS network that links TAs with each other, and Public Technology, Inc. During Phase III, TAs were funded 90 percent by NSF/RANN and 10 percent by local government. As of July 1, 1976, none of the test sites had exercised the option of withdrawing from the program. All of the test site cities started paying 80 percent of the TAs' salaries and overhead and fringes.

The 15 universities, research institutes, and private firms serve as technical backup sites to the UTS (see Appendix A). The primary functions of the backup sites are:

- To support the TAs with whom they are associated by supplying them with technical information, alternatives, and analyses which are

useful to the sites where the agents are located; and

- To identify problems common to more than one site, and to work as part of a team assigned by the System Manager to work on common technical problems.

The UTS program which began on July 1, 1973 and has Federal support through November 30, 1977, is structured to have four phases:

Phase I - Planning activities and System configuration.

Phase II - Technology Agent selection training and placement.

Phase III - Operational phase.

Phase IV - Documentation of System performance.

At present, Phase III is approximately one-half complete.

As the UTS experiment is not complete, the utilization of information related to the achievement of primary program objectives has not been formally evaluated. However, in the operational phase of the UTS program, technology is being introduced into the 27 test sites and the participating local governments are benefiting from the program. The products of this phase of the program are diverse and range from the generation of software to allow more effective utilization of existing computers, to the introduction of a new and improved material for street repair.

Utilization Objectives

At present, during the operational phase, the objective of the UTS program is the utilization of technologies by the test sites to facilitate the delivery of services. The test sites, or user organizations, are characterized by not having high-level technical capability. The TAs and backup sites are structured to overcome this barrier to innovation. The potential users, additionally,

do not represent an aggregated market to which the sources of applicable technological products can respond. The UTS network is expected to allow an aggregation of the needs of local governments so that the Federal government and industry can respond more effectively. Examples of successful and beneficial application of technology within local governments are needed to accelerate efforts to identify and implement innovative applications of technology.

The entire UTS program is a utilization program--a technology utilization program with instrumentation to monitor and allow evaluation of the System's performance. The users, represented by the TAs, are involved in all aspects of the program. When a solution to a specific problem in a test site is found, the communication that takes place between TAs and the UTS network is expected to result in more rapid diffusion of the solution to other test sites faced with the same problem.

PTI is associated with the International City Management Association, the U.S. Conference of Mayors, the National League of Cities, National Governors' Conference, Council of State Governments, and the National Association of Counties. This gives PTI the opportunity to obtain high visibility for the UTS and its accomplishments and thereby enhance utilization of the program's outputs. Additionally, the bi-monthly PTI/News gives the program visibility in a large number of local governments not involved in the UTS program. Finally, the publications and presentations listed in Appendix C may have a positive impact on total utilization of the products of the UTS program.

Utilization Obtained

This section contains an account of utilization which has been made of the UTS program and its products. This includes general capabilities resulting

from the UTS and used by the test site local governments, and specific items of technology utilized by the test sites.

A special report on benefits of the UTS program prepared by Public Technology, Inc. and submitted to NSF/RANN on January 16, 1976, contains a number of letters from representatives of test-site local governments, technical back-up sites, and other individuals describing their views of the benefits of UTS and the utilization that has occurred. Portions of two of these letters are reproduced here for information; the two selected are representative of the letters in the report. The first is from Carleton McMullin, City Manager of Little Rock, Arkansas:

"UTS has both tangible and intangible benefits for communities. In Little Rock, tangible benefits approaching \$500,000/year resulted from the Technology Agent's contributions in improved solid waste collection. At the same time, the TA and the UTS program provided the City with good hard data on state-of-the-art technology for solid waste disposal planning purposes. Other tangible benefits of the UTS program are occurring daily through operations research and productivity studies. For example, a productivity improvement program at the City zoo resulted in manhour savings of approximately 14 percent over hours previously lost through less productive approaches.

"On the intangible side, while difficult to measure, UTS has led to a heightened awareness by key city officials of technology and its benefits in delivery of primary city services and the accomplishment of tasks.

"In short, UTS has been a boon to Little Rock in many ways, not the least of which has been the provision of better information for day-to-day decision making. We sincerely hope that there will be ways of continuing the positive impact of the UTS program to the affairs of the cities."

The second letter is from Ted Tedesco, City Manager, San Jose, California:

"The UTS program has been and continues to be of immense value to San Jose, both quantitatively and qualitatively. The UTS projects that our Technology Agent, Monroe Postman, has been involved in have produced substantial savings to the City. This has been particularly true of the Library Automated Circulation System that he developed. His availability to city staff for advice on technical matters, although not as quantifiable, has certainly been of very positive benefit to the city.

"There is no question that today's local government managers need better technology and more efficient and more productive approaches in

order to help meet ever-increasing costs and greater service delivery demands. UTS is the kind of program that has provided and can continue to provide much of the needed assistance. We would like to see it continue on a federal/private/local partnership basis."

Additionally, the decision by all test site cities to increase their contribution from 10 percent to 80 percent of the TAs' salaries is a very significant and encouraging endorsement of the UTS program.

The remainder of this section is directed to specific cases of utilization of technology, within the 27 test sites. Public Technology, Inc. has formally reported 95 specific cases of such utilization by means of "UTS Briefs." Typical subjects of UTS Technology Briefs are listed in table 35-2. A sample task brief is found in Appendix D.

PTI's special report of January 1976 summarizes the impact of utilization achieved within the 27 test sites. Table 35-3, reproduced from that special report, divides utilization into nine specific categories and a miscellaneous category. For each category of utilization, an estimate of the UTS test site total implementation cost associated with utilization is given. The total UTS test site investment of \$4.2 million includes implementation costs of \$3.4 million and TA salaries and other program related costs of \$800 thousand. Table 35-3 includes an estimate of achieved and anticipated annual cost-savings associated with the innovations which have occurred or are taking place in each of the categories. It should be noted that the achieved and anticipated annual savings of \$6.3 million resulting from work already accomplished by UTS exceed the total test site expenditures as of November 30, 1975. Investment by NSF/RANN in the UTS program was approximately \$2.5 million as of November 30, 1975. Thus, the total investment by NSF/RANN and the test sites was approximately equal to achieved and anticipated annual cost savings by 29 months into the UTS program. Projected annual cost savings can be expected to exceed total

Table 35-2

TYPICAL UTS PROJECTS

Project	Technology Agent	City/County/ Township
Bridge Deck Resurfacing	Greg L. Page	Eugene, OR
Parks Management Sys- tem/Resource Alloca- tion System	E.L. Herman	Akron, OH
Police Manpower Scheduling	John Bayles	Arlington, TX
Energy Conservation in New Office Building	Lawrence P. O'Keefe	Henrico County, VA
Development of Geograph- ically Based Informa- tion System	Robert Svehla	Independence, MO
Traffic Signal Control- ler Diagnostic Equip- ment	J.H. Reynolds	Lower Merion Township, PA
Public Opinion Survey	A.S. Young	West Hartford, CT
Productivity Improve- ment Program	Lee Hodorowski	High Point, NC
School Bus Routing	Allan S. Young	West Hartford, CT
Emergency Medical Services	Richard H. Nordquist	Evanston, IL
Street Lighting Modifi- cations	Allan S. Young	West Hartford, CT
Concrete Road Mainte- nance	Daniel C. King	Kettering, OH

Table 35-3. UTS Network Activities

July 1, 1974-November 30, 1975

Functional Area	Actual UTS Test Site Total Implementation Cost (\$)	Actual Annual UTS Anticipated/Achieved Cost Savings (\$/yrs)
Communications and Dispatch Systems	66,100	117,330
Data Management Systems	106,500	238,800
Energy Conservation	1,362,910	1,236,790
Parks and Recreation	3,000	97,500
Public Buildings	417,000	157,000
Public Safety	52,575	898,000
Solid Waste Management	65,000	1,156,700
Traffic Control/Streets	107,300	346,750
Vehicle/Equipment Maintenance	143,000	163,000
Miscellaneous	1,176,000	1,932,400
TOTAL	3,449,385 + 800,000*= 4,249,385	6,344,270

* represents local governments TA salary and related test site program contributions to-date.

cumulative program costs in 1976 and beyond.

In order to obtain an assessment of the status of utilization of the 95 specific cases reported by PTI, six Technology Agents and four other individuals located in city governments were contacted concerning the reported cases of utilization. (These contacts were made on a random/opportunistic basis.) In the course of the conversations with the individuals, 18 specific applications

of technology were considered within the context of the stage of implementation and the benefits achieved. Details of these contacts are presented in Contact Summaries in the next subsection. The results of these contacts are:

- Of the 18 specific utilization cases considered, 13 have been completely implemented and are functional.
- Three of the utilization cases are at the stage where equipment has been obtained and preparations have been made to complete implementation. (UTS-2,40,72)
- One of the cases has not been implemented because of an institutional barrier. (UTS-75)
- No action has been taken on one case because no decision has been made by the City. (UTS-47)
- Only two clear cases of diffusion to other test-site cities were identified. However, a significant amount of activity to disseminate information on utilization cases was evident.
- The Technology Agents generally viewed themselves as being part of local government, but, there was some indication that the local governments view the Technology Agents as "outsiders."
- The information obtained tends to support cost savings projected by PTI.

Based on the reports available on the UTS program to date, conversations with the NSF Program Manager, Mr. Thomas P. Anderson, the PTI Principal Investigator, Mr. Ronald J. Philips, the PTI Program Director, Mr. James L. Mercer,* and discussions with Technology Agents and other users, it is concluded that a very significant amount of utilization of technology is occurring within the

* Mr. James L. Mercer was PTI Program Director until June 1, 1976.

27 test sites. Further, this utilization is having a significant impact through cost-savings and cost-avoidance.

Contact Summaries

The following paragraphs summarize information obtained from individuals concerning the status of 18 specific randomly selected utilization cases of the 95 cases reported in the UTS program. Six Technology Agents and four other users were contacted.

Mr. John R. Ewen
Technology Agent for
Jersey City, New Jersey

Improvement of Boiler Efficiency (UTS-2) - Mr. Ewen reported that a report prepared by himself and Exxon Corporation on improvement of boiler efficiency has been submitted to the City. Part of the equipment for modification of the housing project boiler has been ordered. Implementation is proceeding slowly because of priorities within Jersey City and as a result of staff reductions that have taken place in the last six months. It was confirmed that estimated savings of \$40,000 annually are expected from the modifications.

Total Energy System (UTS-72) - Mr. Ewen reported that recommendations for a total energy system for the Jersey City Medical Center were prepared by the technical backup site (Exxon), and submitted to Jersey City in September of 1975. Since then, the City has hired a consulting firm, Syska Hennessey, to study Exxon's report and to prepare an implementation plan for the recommended operational and hardware modifications.

Mr. Ewen, at this point, expressed some frustration that progress in general is slow in local government. He indicated that the Technology Agent, although a part of local government, is still viewed as an outsider. It is his opinion that success and time are required to change this situation.

Energy Conservation Demonstration Program, Jersey City - Mr. Ewen indicated

that Jersey City and Aerospace Corporation have been awarded a \$250,000 contract from the Energy Research and Development Administration to demonstrate conservation of energy in four municipal buildings in Jersey City. The buildings that will be modified are the City Hall, two schools, and one other building in Jersey City. The systems to be modified are lighting, ventilation, heating and air conditioning. Projections indicate that the payback period on the investment of \$250,000 is less than two years.

Pothole Repairs (UTS-29) - Mr. Ewen also reported that the Jersey City Public Works Department has used asphaltic material identified by UTS for its entire winter pothole repair program. The results have been completely satisfactory and the Department of Public Works is realizing \$9,000 in annual savings by using this new material. Public Technology, Inc. is proceeding with a 27-test site evaluation program of the pothole patching material.

Card Parking System (UTS-40) - Jersey City has received and has reviewed proposals for planning an implementation of a card parking system identified by UTS. It is Mr. Ewen's understanding that the city will contract with the New York Institute of Technology to perform this planning function.

Underground Leak Detection (UTS-47) - Mr. Ewen indicated that a new leak detection system identified by UTS with assistance from the California Innovation Group has been demonstrated to Water Division personnel in Jersey City. It was recognized that the system was superior to what has been used in Jersey City. In spite of this, a system has not been purchased at the present time. Mr. Ewen has not been able to determine why this is the case.

Mr. John Bayles
Technology Agent for
Arlington, Texas

Alternative Service Bill Delivery (UTS-33) - Mr. Bayles indicated that a test program involving the delivery by city employees of service bills to 4,000

residences in Arlington, Texas began on May 4, 1976. To date they are experiencing no significant problems and only two people of the 4,000 indicated any displeasure at the new approach to delivery of service bills. On the assumption that things continue to go well, the new approach will be utilized city-wide.

Word Processing (UTS-48) - As a result of a technology recommendation, a small computer is now being used effectively by the Convention and Visitors Bureau of Arlington. It is estimated that it would have been necessary to hire two to three additional staff in order to maintain the service being provided at the present time. Other departments within the city including the engineering and legal departments have requested the same capability. Mr. Bayles has not been able to make an accurate assessment of the savings being realized.

Emergency Medical Service (UTS-52) - The City of Arlington made a decision not to implement a plan provided by UTS for a city operated emergency medical service. However, they contracted with a private company to supply these services based on the plan developed by the UTS. This approach was taken because it did not require capital outlay on the part of the city. The major results are that emergency medical services have been significantly improved without an increase in cost.

Police Manpower Scheduling (UTS-7) - Mr. Bayles indicated that a manpower scheduling manual prepared by his backup site is being used in the Arlington Police Department. According to Police Captain Ray Ables, the Department is using the guidelines specified in the scheduling manual. At present, scheduling is still done manually. He expects that they will computerize the process in the near future. The major benefits of the scheduling guidelines are that they force the Department to do a thorough job in scheduling, thus making the operation more effective. He indicated there are no time or cost savings involved in the test phase. Captain Ables also reported that the computerized form of

the manpower scheduling system is already being used in Garland, Texas.

Mr. Joseph Aceves
Technology Agent for
Pueblo, Colorado

Fleet Maintenance Data Processing System (UTS-14) - An in-house computerized city fleet maintenance system recommended for Pueblo has been completely implemented. Cost savings to the City of Pueblo as a result of their handling of their own fleet maintenance data management is at least \$13,000 per year.

Street Striping Paint Selection (UTS-75) - A study of paints for street striping and a recommendation that a chlorinated rubber-based paint be used have not been adopted by Pueblo. Adoption did not occur because the City purchases paint through the purchasing department of the State of Colorado and achieves significant savings by that practice. In this situation, it would be necessary to approach the purchasing department of the State of Colorado to achieve the projected cost savings and other benefits with this innovation.

Retrofitting Existing Housing for Energy Conservation (UTS-62) - Mr. Aceves has been instrumental in the initiation of a program to demonstrate the energy savings that can be achieved by modifications to four existing homes in Pueblo. The City is paying one-half the cost of these modifications. They involve insulation in attics and walls, storm windows, installing attic fans, and weather stripping. A local natural gas company is assisting the city in monitoring fuel savings and it is estimated that these savings amount to approximately 20 percent when corrections are made for annual variations in temperatures. The reaction of the population of Pueblo is reported to be enthusiastic. The city and the gas company are assisting homeowners in surveying their homes to determine what modifications are needed. The gas company is helping citizens finance improvements of this nature in order to achieve significant reduction of fuel consumption in Pueblo.

Mr. Richard Dietz
Urban Observatory
San Diego, California

Mr. Dietz is involved in the California Innovation Group program which is, in many respects, similar to the UTS and is funded by the National Science Foundation. Mr. Dietz indicated he had requested information from Mr. Aceves concerning the Pueblo energy conservation demonstration program. He indicated that a similar program exists in San Diego and is directed toward energy conservation through the use of additional insulation in existing homes. He stated that the information and data obtained was important to San Diego on a comparative basis and in assisting them in evaluating their own energy conservation program.

Mr. Dietz, commenting on the UTS in general, stated that the California Innovation Group communicates with the UTS on a weekly basis and exchanges a significant amount of data and information. Basic information on the construction of soft body armour for police officers was transferred from the California Innovation Group to the Technology Agent in Nashville, Tennessee. The Technology Agent and purchasing department in Nashville prepared specifications for purchasing soft body armour. These specifications were then communicated back to San Diego, California and were used by San Diego for purchasing this equipment. Another example is information sent to San Diego by the Technology Agent in Little Rock, Arkansas on the use of one-man trash collection vehicles. Mr. Dietz indicated this was excellent background information on these types of vehicles and he estimated that San Diego would institute the use of such vehicles sometime in the future. Mr. Dietz stated that the UTS offers to San Diego and other cities a unique communications network for obtaining specific data which may be useful in planning functions and in drafting city ordinances. For example, San Diego, through UTS, requested information on standards in other

cities for park acreage per 100,000 population. This information was received in a very timely manner and has been given to the San Diego Department of Parks and Recreation. The information is being used in San Diego for planning purposes and may result in a new ordinance.

Mr. Howard Koester
Technology Agent for
Pasadena, California

Tax Assessment and Collection (UTS-36) - Mr. Koester reported that as a result of a study performed by himself, the Deputy City Manager, and Revenue Administrator in Pasadena, the tax assessment and collection functions for the City of Pasadena have been transferred to Los Angeles County. This has not involved increased cost for the County of Los Angeles. Thus, savings to Pasadena of \$215,000 annually are realized and do not involve increased cost at another level of government.

Operations Improvement Program (UTS-54) - Mr. Koester also indicated that UTS recommendations for improvement in operations of a number of city departments were being implemented. He reported that cost savings of over \$200,000 annually have been realized through reduction in staff and that additional steps are being taken to reduce costs.

Mr. Buswell, Management Analyst for Pasadena, confirmed Mr. Koester's comments concerning the improvement in operations of city departments. He indicated that additional changes in operations of a significant nature would be implemented, but pointed out that such changes cannot be made immediately. For example, the new director of the finance department will require some time to become familiar with his present situation and the impact of the recommendations on his operation.

Mr. Daniel King
Technology Agent for
Kettering, Ohio

Concrete Road Maintenance (UTS-46) - Mr. King reported that he identified a maintenance program for concrete roadways in Kettering using both Pavon and a sonoloastic joint sealer. Although the potential for cost savings in Kettering is very great, at the present time Mr. King can make no estimate of how the program is going and what the future maintenance program will be. He indicated that this particular program resulted from the presence of a Technology Agent in Kettering but he had not made direct use of the UTS network.

Energy Conservation Program (UTS-26) - Mr. King also indicated that the initial phase of the implementation of a recommended energy conservation program for Kettering has been completed and that the savings in natural gas consumption had in fact been close to 50 percent. Additionally, a 25 percent reduction in consumption of the electrical energy has occurred. Kettering has been awarded the Blue Flame Award by the Dayton Power and Light Company because of this energy conservation program.

Mr. Greg L. Page
Technology Agent for
Eugene, Oregon

Bridge Deck Resurfacing (UTS-1) - Mr. Page stated that use of Wirand Concrete to repair the Ferry Street Bridge in Eugene, Oregon as suggested by the UTS backup site--Battelle Northwest--has met the expectations of the city and that a savings of \$10,000 to the city was realized. He suggested that Mr. Elwood Werry of Battelle Northwest be contacted concerning additional applications of the material. (See Appendix D.)

Mr. Elwood Werry
Battelle Northwest
Richland, Oregon

Mr. Werry stated that Wirand Concrete--developed by Battelle--has been

used to repair bridges in other locations, but not as a result of UTS. The application in Eugene, Oregon was, however, a definite result of the UTS program.

Mr. Werry volunteered the information that as a backup site to Eugene, Battelle Northwest has done much more than has been reported in UTS Briefs. Specifically, this has involved the following:

- A report on firefighting equipment (including European and Japanese equipment) was given to Eugene's Fire Chief.
- An assessment of the economics of using a mixture of leaves and sewer sludge as a lawn fertilizer was performed for Eugene. The report on this study did not conclude that the concept was economical: Eugene tried the concept anyway and is continuing the practice.
- In the area of energy conservation, Battelle assisted Eugene in the use of solar energy to heat a small city-owned swimming pool as a demonstration project. The concept has been implemented and, if it is satisfactory, all public pools in Eugene will use solar heating.
- A report was prepared for the city on the materials and chemicals purchased by the city. The report contained information on what is contained in each substance and the hazards associated with each. This allows the city to take appropriate precautions in the use of the substances.
- The backup site has supplied technical consulting in the areas of noise pollution, selection of paints for different purposes, and approaches to grass burning in seed producing fields.

Mr. Werry went on to state that the UTS is an extremely effective way for technology to be applied to needs in local governments. The person-to-person

interaction is that aspect of the program that makes it successful and is necessary for effective technology transfer.

Features

Public Technology, Inc. is a non-profit research and development corporation having no vested product oriented interest or profit driven service delivery activity. PTI is closely associated with six national and international associations concerned with the problems of state and local government administrative officers. It is an outgrowth of activities initiated within the International City Management Association and thus should have the confidence and cooperation of local government administrators to a significant extent and should be familiar with the problems of working with local governments.

The Principal Investigator, Mr. Ronald J. Philips, has extensive experience in government, technology utilization, and management. The Program Director, Mr. James L. Mercer, has experience as an Assistant City Manager, in a university environment, and as a technical project manager in industry. There have been three NSF Program Managers. However, no specific problems were identified as a result of these discontinuities in program management.

One of the most significant aspects of the UTS is that it is a long-term program with sufficient funding to elucidate to a significant extent questions concerning innovation in local governments and to have a positive impact on operations and delivery of services within the twenty-seven-test site local governments.

The entire operational phase of the UTS program is a utilization effort. It is an effort to apply technology to solve problems in local governments. Also included in the operational phase is an effort to achieve more rapid and

effective diffusion of innovations to other local governments both inside and outside the UTS network.

Although there is no formal user advisory committee involved in the UTS, there is a very significant involvement by users in the program. The test sites and their Technology Agents are users in a real sense. Comments made by TAs in the course of this case study indicate that they generally consider themselves part of the local governments they represent.

Conclusions

Available data and information on the operational phase of the UTS indicate that it is successful in stimulating innovation in the 27-test site, local governments. Technology, procedures, and processes are being utilized by a variety of departments in these governmental units with significant benefits. Requirements are being aggregated and significant information exchange is taking place between the test sites and other city and county governments as a result of the UTS. Annual actual and anticipated benefits in financial terms appear to exceed total, cumulative, test site program costs. The decision of all 27 test site cities to increase their contribution to the TAs' salaries as of July 1, 1976 from 10 percent to 80 percent is a clear indication that the cities consider the programs beneficial.

Among the reported cases of technology applications, a number are not moving as rapidly toward complete implementation and utilization as would be expected. Such factors as decisions that cannot be made by city councils and other bodies, availability and allocation of funds, lack of manpower in the local governments, and decisions on starting efforts within backup sites are involved in such delays.

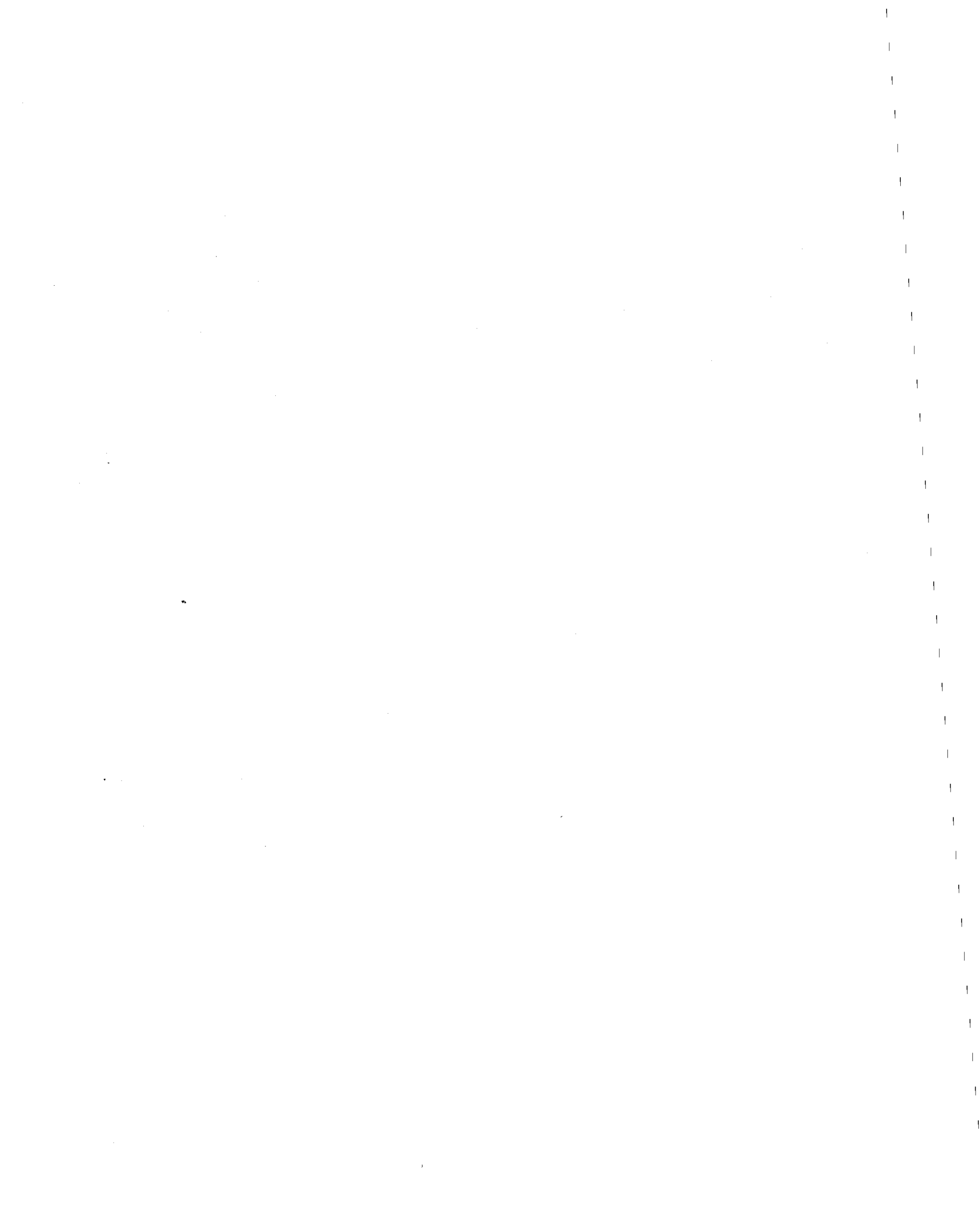
Diffusion of information throughout the UTS network is taking place rapidly, but implementation and utilization are not spreading at a significant pace. This is probably due to the fact that the UTS has been in operation only one and one-half years.

In general, utilization of the products of the UTS program is occurring rapidly and in a beneficial manner within the test sites. It is expected that as the program continues, innovation, diffusion, market aggregation and total program impact will occur at a more rapid pace and with greater impact.

Appendix A

PARTICIPANTS IN THE URBAN TECHNOLOGY SYSTEM

<u>TEST SITE</u>	<u>TECHNOLOGY AGENT</u>	<u>BACKUP SITE (BUS)</u>	<u>BUS REPRESENTATIVE</u>
Akron, OH	E. L. Herman	Gulf and Western ADEC	R. S. Berkof
Arlington, TX	John Bayles	Texas A&M University	Stephen Riter
Atlanta, GA	Larry Madsen	Garrett Corporation	James Tyler
Eugene, OR	Greg Page	Battelle Northwest	E. V. Werry
Evanston, IL	Richard Nordquist	IIT Research Institute	Serge Uccetta
Hampton, VA	Larry Riggs	Grumman Aerospace Corp.	Seymour Winkler
Henrico Co., VA	Lawrence O'Keefe	IIT Research Institute	Serge Uccetta
High Point, NC	Lee Hodorowski	NC State University	Thomas W. Stephenson
Independence, MO	Robert Svehla	Battelle Columbus	Jules Duga
Jefferson Parish, LA	Jack H. Gould	NC State University	Thomas W. Stephenson
Jersey City, NJ	John Ewen	Exxon REC	A. R. Garabrant
Kettering, OH	Daniel King	Battelle Columbus	Jules Duga
Little Rock, AR	Roger Lubin	Texas A&M University	Stephen Riter
Lower Merion, PA	James H. Reynolds	Gulf and Western ADEC	R. S. Berkof
Minneapolis, MN	Norm Yarosh	Bolt, Beranek & Newman	Eric E. Ungar
Nashville, TN	Elmer Young	Urban Observatory of Metropolitan Nashville	D. F. Callahan
Oklahoma City, OK	James Carter	University of Oklahoma	C. E. Barb, Jr.
Pasadena, CA	John Barney	Aerospace Corporation	Sid Firstman
Pueblo, CO	Joseph Aceves	Texas A&M University	Stephen Riter
St. Petersburg, FL	Edmund Boyle	Exxon REC	A. R. Garabrant
San Jose, CA	Monroe Postman	University of California at Berkley	John Cummins
Sioux City, IA	Kenneth Sill	IIT Research Institute	Serge Uccetta
Spokane, WA	Roger Crum	Aerospace Corporation	Sidney Firstman
Topeka, KS	Jose Hernandez	Naval Underwater Systems Center	George C. Connolly
Tucson, AZ	Robert Stutz	Garrett Corporation	James Tyler
West Hertford, CT	David Krans	Grumman Aerospace Corp.	Seymour Winkler
Worcester, MA	Charles Hill	Worcester Polytechnic Institute	Edward N. Clarke



Appendix B

USER ADVISORY COMMITTEE

There is no formal User Advisory Committee in the UTS Program. However, the staff of Public Technology, Inc. and participating Technology Agents located in the 27 test sites view themselves as part of the User Committee. The program participants view themselves as a User Advisory Committee.

There is a Program Advisory Committee. Individuals serving on this Committee are as follows:

Akron, Ohio John Ballard, Mayor	Jefferson Parish, Louisiana Douglas A. Allen, Parish President
Arlington, Texas Ross Calhoun, City Manager	Jersey City, New Jersey Paul Jordan, Mayor
Atlanta, Georgia Jule Sugarman, Chief Administrative Officer	Kettering, Ohio John W. Laney, City Manager
Eugene, Oregon Charles Henry, City Manager	Little Rock, Arkansas Carleton McMullin, City Manager
Evanston, Illinois Edward Martin, City Manager	Lower Merion Township, Pennsylvania Thomas B. Fulweiler, Township Manager
Hampton, Virginia Wendall White, City Manager	Minneapolis, Minnesota Thomas A. Thompson, City Coordinator
Henrico County, Virginia E. A. Beck, County Manager	Nashville, Tennessee Richard Fulton, Mayor
High Point, North Carolina Harold Check, City Manager	Oklahoma City, Oklahoma Jim Cook, City Manager
Independence, Missouri Lyle Alberg, City Manager	Pasadena, California Donald F. McIntyre, City Manager

APPENDIX B (continued)

Members of the Urban Technology System Advisory Committee

Pueblo, Colorado
Fred Weisbrod, City Manager

St. Petersburg, Florida
Ray Harbaugh, City Manager

San Jose, California
Ted Tedesco, City Manager

Sioux City, Iowa
Gary F. Pokorny, City Manager

Spokane, Washington
F. Sylvan Fulwiler

Topeka, Kansas
Harry L. Felker, Parks Commissioner

Tucson, Arizona
Joel Valdez, City Manager

West Hartford, Connecticut
Richard Custer, Town Manager

Worcester, Massachusetts
Francis McGrath, City Manager

Other Members Selected for their Strong Interest
in Local Government Technology Transfer

Robert Coop, Arthur D. Little, Inc.

Eli Freedman, City Manager, Rochester, New York

Hugh McKinley, City Manager, San Diego, California

Appendix C

PROJECT PUBLICATIONS AND PRESENTATIONS

The major publications and presentations resulting from the UTS program are as follows:

R. Custer, "Local government needs more technology than is available," Professional Engineer, Vol. 45, No. 2, Washington, National Society of Professional Engineers, February 1975.

R.J. Philips and J.L. Mercer, "Increasing public sector innovation through urban technology," section of book on technology transfer, edited by Denver Research Institute, to be published by Praeger Publishing Company.

J.L. Mercer, "Urban technology agents placed in cities, counties to stimulate pace of technology transfer," Professional Engineer, Vol. 45, No. 2, Washington, National Society of Professional Engineers, February 1975.

_____, "Urban technology system: a national experiment in local government technology transfer," Proceedings of the 26th Annual Conference, American Institute of Industrial Engineers, May 1975.

_____ et al., "An experimental urban technology extension service," Public Management, August 1973.

_____, "Technology agents," Public Management, December 1974.

J.L. Mercer and A.H. Markham, "Solving the problems of local government: a new approach to technology transfer," Engineering Education, Vol. 65, No. 7 April 1975.

J.L. Mercer and W.M. Mascenik, "UTS: accelerating public sector technology utilization," Proceedings of the Annual Winter Meeting, American Society of Mechanical Engineers, December 1975.

_____, "UTS: solving local problems," Mechanical Engineer, June 1976.

_____, "A Proposal to Establish and Operate an Experimental Urban Technology Extension Service," Washington, Public Technology Inc., April 1973.

J.L. Mercer and M.A. Olstein, Final Report: Methodology Study of an Urban Technology System, Washington, Public Technology, Inc., July 1973.

_____, Urban Technology System Phase I and II Report, Washington, Public Technology, Inc., October 1974.

_____, Urban Technology System Special Report, Washington, Public Technology, Inc., January 1976.

_____, Urban Technology System Annual Report: Phase III (Operations), Washington: Public Technology, Inc., March 1976.

Appendix D

UTS BRIEFS

Public Technology developed and operates the Urban Technology System for the National Science Foundation. The system is managed by UTS, a Public Technology, Inc. subsidiary, 1000 Wisconsin Avenue, N.W., Washington, D.C. 20005

Case Brief

1

August, 1975

BRIDGE DECK RESURFACING

Problem

The Ferry Street Bridge crossing the Willamette River in EUGENE, OREGON, developed cracks in the concrete deck and had other signs of surface deterioration. This bridge was the busiest in the City of Eugene and was identified as a high priority problem by city staff. The design constraints for the deck overlay included:

- Lightweight because the bridge structure could not support much additional deadload.
- Quick construction time because bridge could not be closed.
- Good resistance to studded tires.
- Project work complete within budget.

Solution

The Technology Agent in conjunction with the Public Works Department developed a problem statement and sent it to the Backup Site, Battelle Northwest. A study was performed by Battelle which considered alternative repair techniques given the design constraints. Three recommended solutions were provided and the City selected a rubberized asphalt coating. This material was lower in cost, was able to take greater vibration loads, and is resistant to steel studded automobile tires.

Impact

As a result of an operational UTS network to solve this specific problem the following activities occurred:

- The bridge deck was repaired.

- Oregon State University became interested in the problem and submitted a proposal in the amount of \$65,000 to the National Transportation Research Board for a field evaluation of galvanic cathodic protection.
- The Backup Site recommended not to use expoxy sealant which resulted in cost savings.
- Prolonged life of the expansion joints was made by the use of the Backup Site developed material called (Wirand Concrete) which is a steel fibrous concrete.

Savings

Savings of \$10,000 resulted from the City using the recommendation of the backup site which was not to fill the cracks in the bridge deck with epoxy. Their experience indicated this procedure had limited value in preventing water intrusion for this particular bridge.

Transferability

The problem and solution are well documented and would be completely transferable to any jurisdiction having a similar need. Another UTS test site, Akron, Ohio, was aware of this work and has requested the problem solution for possible implementation.

Contact

Greg L. Page
Technology Coordinator
City of Eugene
P.O. Box 1967
Eugene, Oregon 97401
503/687-5017 or 5010



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 36

ENERGY ABSORPTION CHARACTERISTICS OF STRUCTURAL SYSTEMS SUBJECTED TO EARTHQUAKE EXCITATION

UNIVERSITY OF CALIFORNIA, BERKELEY

Case Investigator:

D. F. Tolman

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

J. C. Smith

Department of Civil Engineering
North Carolina State University
Raleigh, North Carolina 27607

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

ENERGY ABSORPTION CHARACTERISTICS OF STRUCTURAL SYSTEMS SUBJECTED TO EARTHQUAKE EXCITATION

Introduction and Summary

One of the major objectives of earthquake engineering is predicting the inelastic response of structures subjected to severe earthquake excitation. Considerable effort has been devoted to writing computer programs for performing such analyses; however, very early in the development of these programs, it became apparent that much more detailed information on the actual damage performance of such components was needed to validate the programs before reliable computer predictions could be made. To develop such data, an NSF-funded project was initiated at the University of California in 1966.

The project is being conducted by the Earthquake Engineering Research Center (EERC), which was established in 1968 at the University of California at Berkeley. The Principal Investigator is Dr. Ray W. Clough, Professor of Civil Engineering and Director of the Earthquake Engineering Research Center. Project information is given in table 36-1.

The project has continued under the same title for nearly ten years. Funding through April 1976 has amounted to approximately \$4.5 million, of which nearly \$1 million supported the current reporting period (November 1974 to April 1976) summarized in this report. NSF has recently funded next year's follow-on research for approximately \$900,000. In addition to the actual research effort, the total funding financed construction of the sophisticated earthquake simulator facilities required to evaluate the inelastic seismic performance of structures.

Table 36-1

PROJECT INFORMATION

Project Title Energy Absorption Characteristics of Structural Systems Subjected to Earthquake Excitation	Grant/Contract No. AEN73-07732-A02
RANN Program Manager Dr. John B. Scalzi	RANN Program Area Earthquake Engineering
Principal Investigator(s) Dr. Ray W. Clough, Director Earthquake Engineering Research Center	Schedule Start: November 1974 End: April 1976
Institution University of California Berkeley, California	*Funding 11/74 to 4/76 NSF: \$994,500 Total since 1966 - Approximately \$4.5 million
Contributors/Collaborators:	13 Faculty Investigators and 39 Research Assistants
User Advisory Committee:	Separate advisory committee for each sub-project
Precursor Activities:	Previous RANN sponsored research

*There are several other sponsors who have paid for specific tests or series of tests of particular interest to them - exact amounts unknown.

The program of activities includes testing of various structural components in the laboratory and correlating the results with a field test program. Analytical research verified by experimental testing is also being directed toward the development of computational procedures by which engineers can predict the inelastic (nonlinear) response of real structures under strong earthquakes and

assess the potential damage to the structures.

Based on the contacts made and the documents reviewed, it is concluded that the products of this research have been well documented and well utilized over a number of years. Dissemination of the research results in published reports and papers and at conferences and symposia has served to make professionals in the structural design and earthquake-related disciplines aware of their potential use. The research results have been used in practical applications by design engineers and are resulting in changes to seismic design building codes. Since structural response to earthquakes is important throughout the United States and the world, the utilization of this research is expected to continue and increase in the future.

Research Description

A major objective of this project has been to improve the capability of predicting the response of structures to earthquakes through the use of analytical digital computer procedures. The general approach has been to develop testing facilities capable of subjecting structures to simulated earthquake loadings, to measure the performance of a variety of structures during such tests, and to use the experimental results in defining mathematical models which reliably and accurately represent the observed performance.

The complexity of building structures and their response to earthquake motion is of concern not only in California and western United States, but throughout the world in areas with moderate or major earthquake expectancy.

A general approach to structural response analysis is to model each of the members or components which comprise the complete structure and then to mathematically assemble these component models so that they simulate the

behavior of the complete structure. However, the effectiveness of this approach can only be tested by correlation of the analytically predicted behavior of complete structures with observations of the performance of the complete structures. For this reason, a major aspect of the total research effort has been directed toward observation and evaluation of the seismic behavior of complete building systems assembled from a number of structural elements and components.

The principal experimental facility which has been developed for study of complete structures is the Earthquake Simulator Facility at the Richmond Field Station which first began its pilot runs in 1972 and has been in full operation since March 1973.

The Earthquake Simulator Facility is a specially designed building, 60 x 120 x 40 feet, in which the earthquake simulator and associated control and data recording facilities are housed. The central feature of the facility is the 20 x 20 feet "shaking table" or earthquake simulator. The table, on which test structures or components are placed, can move in the vertical and one horizontal direction. Test structures weighing up to 100,000 pounds can be subjected simultaneously to horizontal and vertical motions of about twice the intensity of those experienced in the 1940 El Centro quake. The shaking table, a heavily reinforced concrete platform, is hydraulically actuated to impart vertical and horizontal accelerations of sufficient amplitudes to cause inelastic deformations in the test structure. Appropriate instrumentation is used to measure and record these deformations.

Other facilities include dynamically controlled displacement test systems at the structural research laboratories both in Richmond and in Berkeley, high speed digital data acquisition systems for both laboratories, and field vibration test systems.

The program of activities includes testing of structural components such

as reinforced concrete beams and beam-columns, reinforced concrete beam and column sub-assemblies, and reinforced concrete frames with partial exterior walls. The moderate-size earthquake simulator is used to verify, extend, and modify analytic understanding of the earthquake response of steel rigid and braced frames, reinforced concrete frames, reinforced concrete frames with structural walls, and masonry structures. The results of these experimental activities are correlated with theory and compared with results of a separate field test program. Concurrent analytic research is directed toward developing computational procedures with which engineers can predict, with sufficient accuracy and economy for practical purposes, the inelastic response of real structures under strong earthquakes, the amount of damage likely to result, and the possibility of complete collapse.

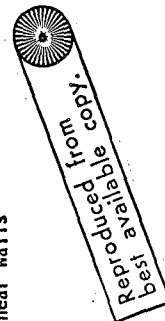
During this research project, the number of faculty and students participating in it grew steadily to a maximum of 13 faculty investigators and 39 research assistants (including 20 Ph.D. candidates). During the present funding period, the project was organized into 16 sub-projects, each with its own budget allocation and user advisory committee. A listing of these sub-projects is shown in table 36-2. The first eight are analytical in nature and the last eight are experimental in nature. Table 36-2 also shows the number of Ph.D. dissertations, the number of reports and papers, and the number of conferences and symposia associated with each sub-project.

The following major products resulted:

- Eighty-eight reports and papers were published or are in progress.
- Thirty-eight reports and papers were presented or will be presented at conferences or symposia.
- Eighteen Ph.D. dissertations were completed or are in progress.
- "The Journal of the International Association of Earthquake

Table 36-2. Listing of Sub-projects

Sub-Project Number	Sub-Project Title	Budget Allocation	Faculty Investigator(s)	Number of Ph.d. Dissertations	Number of Papers & Reports	Number of Conferences and Symposiums
<u>Analytical</u>						
A-1	Computer Programs SAP & NONSAP	\$ 30,124	E. L. Wilson	1	5	1
A-2	Nonlinear Computer Program DRATN-2D	23,441	G. H. Powell	1	2	-
A-3	Lateral-Torsional Seismic Response of Buildings	26,867	A. K. Chopra	1	2	2
A-4	Coupled Shear-Wall Buildings	16,746	A. K. Chopra	1	-	-
A-5	Nondeterministic Studies	28,819	J. Penzien	-	2	1
A-6	Optimal Design Methods	53,167	K. S. Pister/ E. Polak	-	5	-
A-7	Energy Absorbing Devices	27,625	J. M. Kelly	1	5	-
A-8	Post-Earthquake Damage Analysis	30,842	V. V. Bertero	2	11	7
<u>Experimental</u>						
E-1	Earthquake Simulator Studies	194,299	R. W. Clough/ H. D. McIven	3	8	6
E-2	Component Tests	51,497	J. Penzien/ V. V. Bertero	1	3	2
E-3	Spandrel Walls	72,344	J. G. Bouwkamp/ V. V. Bertero	2	4	2
E-4	Ductile Frames	74,794	E. P. Popov/ V. V. Bertero	3	14	7
E-5	Infill Frames and Shear Walls	102,389	V. V. Bertero/ E. P. Popov	2	8	5
E-6	Masonry Structures	105,463	R. W. Clough	-	9	2
E-7	Field Measurements	46,292	E. L. Wilson/ J. G. Bouwkamp	-	5	1
E-8	Braced Frames	49,791	R. W. Stephens/ J. Potrovski	-	5	2
Totals		\$ 994,500		18	88	38



Engineering," edited by Dr. Clough and devoted to earthquake engineering and structural dynamics, has been published quarterly.

- Copies of structural analysis computer programs have been made available for purchase through the National Information Service in Earthquake Engineering and are in use by other researchers and engineers in industry.
- A library on earthquake engineering has been established at the Earthquake Engineering Research Center (EERC).

Results and practical applications of the eight analytical sub-projects and eight experimental sub-projects are summarized in tables 36-3 and 36-4, respectively.

Utilization Objectives

Although the ultimate beneficiaries of this research project might be considered to be the general public, the general characteristic of the direct users are professional engineers and scientists, particularly structural engineers, in the field of Civil Engineering who are concerned with the dynamic response of structures subjected to earthquake loading.

Existing or potential user organizations would include:

- other university researchers,
- private structural design consulting engineers,
- building code organizations,
- public transportation organizations,
- public and private utility companies, and
- industrial firms and trade associations.

The most likely direct users are those professionals concerned with the design, construction, certification, and operation of structures.

Table 36-3

Results and Practical Applications of Analytical Sub-Projects

A-1 Computer Programs SAP & NONSAP

Approximately 600 copies of the program SAP IV have been purchased through the National Information Service in Earthquake Engineering and are in use in industry; also 200 copies of the program NONSAP have been distributed similarly. These programs are widely used structural analysis computer programs.

A-2 Nonlinear Computer Program DRAIN-2D

DRAIN-2D is finding wide use in the analysis of nonlinear earthquake response, both by other investigators at Berkeley and also in industry. ANSR-I was used in an investigation of the ultimate strength of steel tube piles for the Trans-Alaska Pipeline.

A-3 Lateral-Torsional Seismic Response of Buildings

The principal objective of this research has been to develop simple procedures for analysis of earthquake response which can be conveniently utilized in design of buildings.

A-4 Coupled Shear-Wall Buildings

The principal objective of this research has been to develop effective procedures for analysis of earthquake response of coupled wall buildings, and better understanding of the performance of such buildings during earthquakes. The results obtained are expected to be useful in design of such buildings.

A-5 Nondeterministic Studies

There is a growing demand for seismic response analyses of selected systems such as three-dimensional piping systems, nuclear power plant components, highway bridge structures and earthfill dams. Defining the earthquake inputs through a stochastic model has the distinct advantage that dynamic analyses yield mean values and variances of response consistent with the variations to be expected for future ground motions; thus, stochastic modelling as developed in this investigation is of direct practical value.

A-6 Optimal Design Methods

This research was directed toward developing a rational methodology for performing earthquake design based on mathematical optimization theory. The methodology will permit trade-off studies between cost of protection against potential damage and risk of occurrence.

A-7 Energy Absorbing Devices

Energy absorbing devices have been demonstrated to limit the amplitude of response of uplifting (tilting) structures, and thus to increase the feasibility of uplifting designs. In fact, railway bridge structures in New Zealand have now been built which make use of this principle. The same mechanism should also serve effectively to control the amplitude of motion of buildings with a "soft" first story, and such applications will be tested in the future.

A-8 Post-Earthquake Damage Analysis

Investigations performed during this project have provided an opportunity to develop and further improve computer programs for nonlinear seismic analysis, and to demonstrate their effectiveness by correlation with actual building behavior during earthquakes. Studies of damage patterns have lead to concepts for improving seismic design, and these are now being employed in the development of the new ATC-3 seismic design code.


Reproduced from
best available copy. 

Table 36-4

Results and Practical Applications of Experimental Sub-Projects

E-1 Earthquake Simulator Studies

Tests have dramatically shown the great seismic resistance of well-designed concrete building frames, and the significant advantages that may be realized by permitting uplift of building frame footings rather than anchoring them as is required by current codes.

E-2 Component Tests

The mathematical model established through the results of the experimental investigation is of practical use as an element of an overall building model which can be used in predicting seismic performance. Obviously, such predictions have a direct influence upon design.

E-3 Spandrel Walls

The performance of spandrel girder-column systems designed by current U.S. code provisions was evaluated. Brittle failures resulting from inadequate shear capacity were noted, and recommendations of improved reinforcing details to provide increased seismic resistance were made.

E-4 Ductile Frames

Suggestions have been made to preclude brittle failure of reinforced concrete girders near their attachment to heavy columns, including the concept of inclined web reinforcement. The possible failure of column-girder connections by pulling of the main beam reinforcement through the column has been identified, and a remedy based on forcing the plastic hinge to develop in the girder at some distance from the column has been proposed.

E-5 Infill Frames and Shear Walls

Results obtained to date demonstrate the need for improving present design philosophy and code provisions for structural systems employing concrete or masonry infilled shear walls. Present code provisions may lead to an unconservative estimate of the forces to which the walls will be subjected.

E-6 Masonry Structures

Strength properties measured in tests of the two-pier masonry panels are being compared with strengths determined by other testing procedures, and it is expected that recommendations can be made for a standard test procedure to determine seismic strength of masonry. Also, the adequacy of present Uniform Building Code of the International Conference of Building Officials and proposed Applied Technology Council seismic design provisions is being evaluated.

E-7 Field Measurements

Results of the masonry building study will serve to improve dynamic analysis procedures for rigid masonry-type buildings--accounting for soil flexibility and floor diaphragm flexibility in the mathematical models. The results of the steel frame building study have helped to verify mathematical modelling procedures for very complex building frame systems of unusual and arbitrary geometry.

E-8 Braced Frames

It is expected that results of this test program will be applied directly in developing seismic design criteria for braced steel frame construction. However, these studies have not yet been carried far enough to permit reliable conclusions to be drawn.

Reproduced from
best available copy.

Utilization of this project was achieved through extensive distribution of the research results to professionals concerned with the response of structures subjected to earthquake loading.

Of the 88 reports and papers published or in progress, 38 were presented or will be presented at conferences and symposia. There were also 18 Ph.D. dissertations completed or in progress during the research period between November 1974 and April 1976.

Utilization Obtained

Many of the research results have been used in practical applications by design engineers and are resulting in changes to seismic design codes. The research project is long term and continuous in nature and the results should be evident in building codes for many years before more refined research results replace them.

The Journal of the International Association of Earthquake Engineering, edited by Dr. Clough, the Principal Investigator, is published quarterly and has a wide circulation among researchers and practitioners in the field. Copies of structural analysis computer programs, available for purchase through the National Information Service in Earthquake Engineering, are being used in industry. In addition, these computer programs are widely used by structural analysts throughout the world.

The following organizations were contacted by telephone to determine the nature of their utilization of the research products. The contacts include a wide range of individuals and agencies concerned with the earthquake resistance of structures.

Federal Agencies

Dr. Charles G. Culver
Disaster Research Coordinator
Office of Housing and Building Technology
Center for Building Technology
National Bureau of Standards
Washington, D.C.

Dr. Culver is involved in all aspects of building technology including the study of structural resistance to earthquakes. He is very familiar with the research and has read many of the reports. He said that the National Bureau of Standards (NBS) conducts similar, but non-overlapping research; they use the EERC research results to provide a starting point for some of their own work. NBS is also developing provisions for a national seismic design code and some of the EERC research results are being used.

Dr. Walter Fisher
Chief of Structural Mechanics Branch
U.S. Army Construction Research Laboratory
Champaign, Illinois
(Corps of Engineers facility)

Dr. Fisher is familiar with the research and has read many of the reports. He indicates that they have used some of the research results which have influenced the direction of some of their work. They have also used the SAP computer program developed by EERC. Dr. Penzien, EERC, was used as a consultant in the design and construction of the Corps of Engineers' smaller 12' x 12' shake table located at the Civil Engineering Research Laboratory, Urbana, Illinois.

Mr. James Lefter
Director of Civil Engineering Services
Veterans Administration
Washington, D.C.

Mr. Lefter is familiar with both the analytical and experimental research

and has served on advisory committees for EERC. Engineers in the agency, as well as consulting engineers to the agency, have used the computer programs, analytical procedures, and experimental research results in the design of Veterans Administration buildings. Mr. Lefter is particularly interested in infill frames and shear walls, unreinforced masonry structures, and the earthquake simulator studies.

Regional and Local Agencies

Mr. Walter A. Brugger
Chief of Building Bureau
City of Los Angeles
Los Angeles, California

Mr. Brugger is well acquainted with the research which he describes as "good, practical, and well thought out." He thinks that the analytical work on structural walls is very valuable and the experimental earthquake simulator studies "add a new dimension" to information available to the engineering profession. His office has used some of the research results in analyzing earthquake resistance of existing buildings. He also observed that the research results are considered by various code committees for incorporation into building codes.

Mr. John Holstein
International Conference of Building Officials
Whittier, California

Members of the conference are primarily local building officials concerned with building codes and review of proposed code changes. He reported that the conference is continually collecting information developed by EERC for use in code change evaluations.

Mr. John McKinnon
Building and Safety Director
City of Torrance
Torrance, California

Mr. McKinnon is involved with building codes and is a member of the International Conference of Building Officials which publishes the building code for the design of buildings subject to wind and earthquake forces. He is aware of some of the research and, although he has not used the research results directly, he felt that it often served as the basis for building design and for consideration of code changes submitted by the Structural Engineering Association of California.

Academic and Research Institutions

Professor Robert D. Hanson
Department of Civil Engineering
University of Michigan
Ann Arbor, Michigan

Professor Hanson is very familiar with the research, has had extensive exchange of information with EERC, and he or his graduate students have read most of the reports and papers. He rates the Berkeley staff as "very strong" and the experimental and analytical work as "outstanding and cost effective."

Professor Hanson has used both the SAP and the NONSAP Computer Program as well as the non-linear Computer Program DRAIN-2D in his teaching and research work. He considers DRAIN-2D to be a very valuable program and predicts that the utilization of this "less universally accepted" program will increase in the future. He has used the 20' x 20' "shake table" at Berkeley for some of his own NSF-sponsored research.

Professor Mete A. Sozen
Department of Civil Engineering
University of Illinois
Urbana, Illinois

Dr. Sozen's principal interest is in structural dynamics of reinforced concrete structures. He is well acquainted with the project, has read many of the reports and papers and has used the computer programs. He expressed the opinion that, while most of the sub-projects were well-conducted and useful, the total program may be so large that it is unmanageable and requires excessive administrative demands on the Principal Investigator.

Dr. Sozen has a related RANN research project with NSF.

Dr. Robert V. Whitman
Professor of Civil Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dr. Whitman is actively engaged in developing structural requirements for earthquake resistance in buildings. He is very familiar with the research project and his office receives copies of all the publications produced by EERC. He said that these publications form a part of their working library and each is circulated to appropriate faculty when they are first received. Dr. Whitman is particularly interested in the non-linear computer programs which he uses in his own related research.

Professor George W. Housner
Department of Engineering and
Applied Science
California Institute of Technology
Pasadena, California

Professor Housner's field is Earthquake Engineering and he has read or obtained copies of most of the reports and papers by EERC. He has used the non-linear computer program DRAIN-2D in his research work and has followed the design and test results of the earthquake simulator (shake table). Professor Housner

believes that the research is particularly useful to the design engineering profession and that the long-term potential is tremendous.

Business and Industry

Dr. Gordon A. Strickland
Chevron Oil Field Research Company
La Habra, California

Dr. Strickland is involved in research and development. He has worked closely with the Principal Investigator and other faculty investigators on recent experimental and analytical research on the dynamic response of test tanks on the "shake table," sponsored by a consortium of oil companies and NSF. He has read many of the research reports, has used the SAP computer program, and says he has benefited greatly from the research.

Dr. Strickland ranks the research as very useful, and much of it is ready for immediate application by the design profession.

Mr. Roland A. Sharpe, Chairman
Engineering Decision Analysis Co.
Palo Alto, California

Mr. Sharpe heads a structural consulting engineering firm and is Executive Director of the Applied Technology Council and Chairman of the Seismology Committee of the Structural Engineers of California.

He characterizes the research as "high quality work" and the staff as "very active" and effective within the profession.

The research results are continually being discussed within professional groups concerned with structural design and code formulation and serve as the basis for decisions in many cases.

Mr. Joseph Kallaby
Earl and Wright Engineers
San Francisco, California

Mr. Kallaby is a structural consulting engineer specializing in the design of offshore oil platforms. He is familiar with the earthquake simulator studies and is particularly interested in the sub-project on braced frames. He has used some of the research concepts in his designs and, in one instance, the Principal Investigator has reviewed his work.

In general, he said that insufficient research has been done in testing complete structural systems as opposed to individual component testing. Mr. Kallaby would like to see more test work done on the buckling behavior of round pipe bracing. He was very complimentary of the research program and particularly, the staff.

Mr. J. Nicoletti, Chief Engineer
J.A. Blume and Associates
San Francisco, California

Mr. Nicoletti explained that his firm is a structural consulting engineering company specializing in seismic and dynamic research, analysis, and design of structures. Their design engineers are familiar with the research, read the reports, use pertinent information, and contact the individual sub-project investigators for more specific information when required. Their particular interest is in the experimental test work on reinforced concrete and structural steel building frames.

Mr. Henry J. Degekolb, President
H.J. Degekolb and Associates
San Francisco, California

Mr. Degekolb is also President of the Earthquake Engineering Research Institute. He is very familiar with the project and has used many of the

concepts developed in the research for evaluating complex structural designs in his own firm. He was highly complimentary of the project and research staff and emphasized that the research is tailored to meet immediate design needs and building code improvements. Mr. Degekolb views the research program (analysis and test) as "absolutely vital" for improved earthquake design and building codes. He hopes that a larger earthquake simulator "shake table" will be built in the future to study earthquake response behavior of larger test specimens. He also thought that the separate advisory committee for each sub-project was important for planning the respective research objectives.

Features

The utilization obtained to date has been extensive. Major users include professional engineers and scientists concerned with the dynamic response of structures subjected to earthquake loading.

A major factor in the utilization achieved thus far has been the Earthquake Engineering Research Center (EERC) itself. Established in 1968 as an organized research unit of the College of Engineering, the Center's primary function is to facilitate and coordinate earthquake engineering research on the Berkeley Campus of the University of California.

The role of the Principal Investigator and the faculty investigators for each of the sub-projects has also had a significant effect on utilization. The capable EERC staff has been active professionally in the field of earthquake engineering for many years. They have prepared many papers and reports, and have participated frequently in conferences and symposia throughout the world.

Another major factor is the sophisticated experimental facilities for

evaluation of inelastic seismic performance of structures. These excellent supportive facilities include the Earthquake Simulator Laboratory at the Richmond Field Station, dynamic controlled displacement test systems at the structural research laboratories both in Richmond and in Berkeley, high speed digital data acquisition systems for both laboratories, and field vibration test systems.

Since initial funding in November 1966, extensions to project funding have continued smoothly until recently. Early this year, there was a delay of several months in funding next year's research effort. Although this funding delay posed a temporary problem for the EERC, research did continue during this interim period with financial assistance from the University of California.

Another recent problem has been the increasing demands on the time of the Principal Investigator to manage a research project of this size in addition to his teaching responsibilities. This problem has been handled by assigning several co-principal investigators to next year's research effort to assist the Principal Investigator in the administration of this large research project.

Most of the users or potential users interviewed were asked if the technical content of the many reports and papers was appropriate for their needs. The response was favorable, i.e., the contents were judged practical and useful by those contacted.

The Principal Investigator views this as a long-range project requiring a long-term funding commitment. In addition to the actual research, total funding has also financed construction of some of the sophisticated experimental and simulator equipment. Much of the on-going research is a continuation of earlier work conducted over several years on the behavior of structural components and building frames of various materials and types of construction.

Even after computer models or programs are validated through test results, 6 to 12 months are required to document and publish the results of a major experimental program. After that, it may take another year before the findings are recommended for incorporation to seismic building codes, because the recommendations as developed are verified by actual experience before submission to code groups.

Conclusions

The Earthquake Engineering Research Center is a good dissemination vehicle of the research products to professional users. This dissemination is accomplished through numerous reports, papers, conferences, symposia, short-courses, and computer programs, all of which may be obtained from the Center.

The Principal Investigator and staff are active in local structural engineering associations and building code committees which facilitate the use of the research results in practical designs by the professionals and, ultimately, the inclusion of research results into model building codes.

The unanimous opinion of all those contacted is that the Berkeley program, combining analytical and experimental work, is very well utilized and has been for a number of years.

The long-term utilization of the project will greatly contribute to more realistic seismic design building codes and simultaneously enhance the knowledge of those professionals who design structures to withstand earthquake forces.



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 37

METROMEX

ILLINOIS STATE WATER SURVEY
UNIVERSITY OF CHICAGO
UNIVERSITY OF WYOMING
STANFORD RESEARCH INSTITUTE

Case Investigator:

F. M. Vukovich

Research Triangle Institute

P.O. Box 12194

Research Triangle Park

North Carolina 27709

Technical Reviewer:

E. Droessler

Department of Geosciences

North Carolina State University

Raleigh, North Carolina 27607

Prepared under:

Contract No. NSF-C76-17165

National Science Foundation

Research Applied to National Needs

1800 G Street, N.W.

Washington, D.C. 20550

METROMEX

Introduction and Summary

In the last decade, the results of a series of studies (refs. 1,2,3,4, 5,6) strongly suggested that urbanization and industrialization may inadvertently modify weather processes, particularly the development of rain downwind of an urban complex. The results of these studies were not conclusive because of the limitations on data available for analysis. Subsequently, a multi-institutional research effort known as METROMEX (Metropolitan Meteorological Experiment) was initiated by the National Science Foundation (NSF) in 1970 to quantify, discover causes for, and assess the consequences of urban-induced weather effects.

The principal objectives of METROMEX are to determine the extent and location of the effects of the urban area on precipitation and related weather conditions; to discover causes for these effects both over the city and downwind over suburban and rural areas; and to develop methods for predicting these results and translating them to other urban complexes. The city of St. Louis was chosen as a representative site for the initial studies since it is situated in the center of a large rural area in which there are no other major sources of contamination within a radius of at least 100 miles. The city contains a large metropolitan area, coupled with an industrial area and power generating sites.

Initial funding of this project was accomplished through the Division of Atmospheric Sciences of NSF and transferred to the Research Applied to National Needs (RANN) program. The project-funded Principal Investigators

include Mr. Stanley Changnon, Jr., Dr. Harry Ochs of the Illinois State Water Survey; Dr. Edward Uthe of Stanford Research Institute; Professor Roscoe R. Braham, Jr. of the University of Chicago; and Mr. August H. Auer, Jr. and Dr. Richard Dirks of the University of Wyoming. Additional project information is given in table 37-1.

Table 37-1.
PROJECT INFORMATION

Project Title METROMEX	Grant/Contract No. ISWS- UW-AENV-7611260 VC- SCI-GI34770
RANN Program Manager Mr. C. Downie	RANN Program Area Inadvertent Weather Modification
Principal Investigator(s) S. Changnon - Illinois State Water Survey H. Ochs - Illinois State Water Survey R. Braham - University of Chicago A. Auer - University of Wyoming R. Dirks - University of Wyoming E. Uthe - Stanford Research Institute	Schedule Start: 1971 End: 1976
Institution Illinois State Water Survey University of Chicago University of Wyoming Stanford Research Institute	Funding NSF: \$2,980,000 Other: EPA } Dollar Amount AEC } Not Known
Contributors/Collaborators:	Battelle Pacific Northwest Laboratories Argonne National Laboratory
User Advisory Committee:	None
Precursor Activities:	La Porte, Indiana Study

Summer rainfall is significantly higher in the area downwind of St. Louis than in comparable, surrounding areas. The difference is as much as 30 percent in some areas. This precipitation tends to occur in brief periods of high intensity, often including hail. The net effect of this altered precipitation

is a two to five percent increase in agricultural yield and about a six percent differential in the value of farmland.

Utilization of the results of Project METROMEX has been widespread. It has affected local, State, and Federal governmental agencies; business and industry; the general scientific community; the news media; and the general public. Some documented examples of the general utilization achieved or the results of project METROMEX are listed in table 37-2.

Table 37-2
Examples of Utilization

User(s)	Utilization Achieved
Energy Research and Development Administration (ERDA)	Energy development strategies
Environmental Protection Agency (EPA)	Pollution control strategies
Federal Aviation Agency (FAA)	Criteria for major airport design
Illinois Division of Water Resources	Hydrological studies
Illinois Environmental Protection Agency	
Power companies	Atmospheric quality impact studies
Engineering consulting firms	Designing storm water and sewage systems
Urban and regional planning agencies	Zoning regulations
Crop and property insurance industry	Rate setting
Agriculturalists	Engineering design and agronomics
Hydrologists	Design of water treatment systems
Television	Public information

The primary factor contributing to the widespread nature of the utilization of the project results has been the effort of the participants to make the results known to the general user community through presentations, publications, workshops, reports, and the news media. Although all the participants influence utilization, the primary force motivating utilization was Mr. Stanley Changnon, the Principal Investigator from the Illinois State Water Survey.

Research Description

In the early 1960's, some initial evidence was reported in contemporary journals (refs. 1,2,3,7,8) suggesting that urbanization and industrialization may influence local precipitation patterns. It wasn't until the late 1960's, however, that evidence became sufficient to allow serious consideration of the potential of urbanization and industrialization for modifying weather phenomena. The report on the "La Porte Weather Anomaly" (ref. 5) was probably the single most important study of this period in pointing out the effects of urbanization on downwind weather phenomena. La Porte, Indiana is immediately downwind of Chicago, Illinois. A local precipitation maxima relative to the surrounding regions was found in and around La Porte.

Based on this and similar results from other studies, METROMEX, a multi-institutional research project, was initiated in 1970. The project endeavored to quantify, discover causes for, and assess the consequences of urban-induced weather effects. METROMEX was also concerned with the impact of increased use of coal, the effects of a huge concentration of electrical energy generators, and the long-range consequences of air pollution on weather and climate. St. Louis, Missouri was chosen for the study area because it was situated in the

center of a large rural area with no major sources of contamination within 100 miles of the City.

METROMEX, an inadvertent weather modification program, was initially funded by the Division of Meteorology, NSF. When RANN was established, it took control of the management of all NSF-funded research in inadvertent weather modification. METROMEX remained under the auspices of RANN from 1971 to date. Practically all present inadvertent modification research is focused within the METROMEX program.

The Principal Investigators, and their institutions and areas of interest, are listed below:

Mr. Stanley Changnon
Dr. Harry Ochs
Atmospheric Sciences Section
Illinois State Water Survey
P.O. Box 332
Urbana, Illinois 61802
RESEARCH AREA: Rainfall patterns, cloud
physics and urban meteorology

Prof. Roscoe R. Braham, Jr.
Biophysics Laboratory
University of Chicago
5734 South Ellis Avenue
Chicago, Illinois 60637
RESEARCH AREA: Cloud physics and
radar meteorology

Mr. August H. Auer, Jr.
Dr. Richard Dirks
Dept. of Atmospheric Sciences
University of Wyoming
P.O. Box 3038
University Station
Laramie, Wyoming 82070
RESEARCH AREA: Cloud physics
and urban meteorology

Dr. Edward Uthe
Stanford Research Institute
333 Ravenswood Avenue
Mineral Park, California 94025
RESEARCH AREA: Urban atmos-
phere structure

Besides the scientific goals of METROMEX (the investigation of the effects of a large urban complex on the frequency, amount, intensity, and duration of clouds, precipitation, and related severe weather), the application-related goals in METROMEX were to carry out the studies and develop techniques so that the results can be transferred to other urban areas, i.e., to predict the urban effects on weather in other cities; to make the results available to a wide variety of users in scientific, government, and business communities; and to

provide the basis for studies of the potential changes in climate relating to megalopolitan effects and other major anthropogenic activities. The specific tasks of the research include:

- mapping locations of meteorologically important aerosol particles and cloud nuclei, including their sources and areal distribution;
- mapping regions of urban-altered rain clouds and severe storms using radar;
- observing and analyzing life cycles of cumulonimbus clouds as modified by the urban plume;
- defining the urban-induced rainfall and severe weather anomalies;
- determining the structure of the urban-influenced boundary layer and altered boundary layer processes; and
- analyzing all observations and synthesizing results.

In order to accomplish the objectives of the research program, a field program was established. The data derived from the field program were obtained from a surface network, remote sensors (lidars and radars), and instrumented aircraft. The surface network included rainfall measurements from 245 recording rain gauges; hail observations from 245 hail pads; temperature from 28 sites; surface winds from seven sites; upper air boundary layer winds from up to 12 sites with pibals and radiosondes; thunder occurrences from 10 sites (six of these with automatic recording devices); and rain and air chemistry data from 93 sites. In addition to these major surface installations, other specialized equipment, such as cloud cams, were implemented for brief excursions in the field.

Instrumented aircraft were used to release traces into convective updrafts, as well as to obtain measurements of condensation nuclei, temperature, moisture,

and updraft speeds in convective clouds.

Three weather radars were employed in the program. Two were located at Pere Marquette, northwest of St. Louis, and one at Greenville, 50 miles east of St. Louis. These were used to examine the morphology of precipitation production, movement of clouds, and the three-dimensional, time-varying structure of convective cells as they traversed the METROMEX study region.

It was shown that the average runoff in small basins just east (downwind) of St. Louis is increased by 10 to 15 percent compared to regions west of the City. Heavy rainfall rates in short durations (5 to 180 minutes) east of St. Louis are twice as frequent as in any other direction. These alterations in heavy rainfall rates impact directly on storm runoff, bringing a doubling of local flooding occurrences and overloading of wastewater treatment plants for systems with sanitary and storm sewers not adequately insulated from each other, thus producing increased water pollution. The streams in basins east of St. Louis contain up to 20 percent more pollutants than in surrounding areas, partially due to the added rainfall that helps scavenge the urban atmospheric pollutants. Ground water pollution has increased in a similar degree. These data and other METROMEX rainfall and stream water quality data are key inputs to the testing and development of hydrological and water quality models.

The agricultural impacts due to the increased storms downwind of St. Louis are as follows: There is an increase in hail frequency and intensity within an area of 3000 square kilometers east of St. Louis that accounts for a relatively large crop loss. On the plus side, the overall increase in summer rain leads to an increase in crop yield in the same area. The net effect of the altered precipitation is a two to five percent increase in grain crop yield, amounting to an average annual profit of 1.7 million dollars in the area affected by

St. Louis. The increase is most noticeable in dry or near normal rainfall summers. The urban rain effect has provided a higher and more stable farm income, and values of agricultural land in this downwind area are about six percent higher than land in the surrounding areas.

This project is producing a great deal of information that impacts our understanding of changes in climate and weather processes associated with urbanization and industrialization. It is found that summer rainfall is up to 30 percent greater east of St. Louis than elsewhere in the area. The major precipitation changes in and east of the urban industrialized areas seem to occur during periods of severe storm activity when nature is capable of producing moderate to heavy rain. There is an increase in heavy rain days of 60 percent or more, a 25 percent increase in thunderstorm activity, and an 80 percent increase in hail storms and hail intensities in and just east of the City. Storms that have passed over St. Louis produce up to 200 percent more large raindrops, and larger and more numerous hailstones than do rural storms. The City appears to act as a trigger for clouds and rain activity. This activity is often found in the urban-induced convergence zone, and the place and amount of activity depend on the surface conditions, direction of flow, and degree of atmospheric instability.

Utilization Objectives

In terms of potential user groups, it was thought that some of the METROMEX results may have impact on those State and Federal agencies that must encourage development or establish controls based on environmental impacts related to energy production and other human alterations of land surfaces.

The impact of METROMEX results on agriculture was expected to be in terms

of information on rainfall as it would affect crop yield, or on severe storms as it would affect crop losses.

Impacts in hydrology were expected to be in terms of water resource management and facility designs relating to water quality and quantity.

A variety of precipitation-related impacts to be identified by METROMEX were thought to have general planning-related applications for cities, suburbs, and industry. For example, the crop and property insurance industry would be interested in the results in terms of setting insurance rates, and city planners and engineers would be interested in the results for their use in designing storm water and sewer systems, and designing and modeling water quality systems.

Another potential user group is atmospheric scientists, since the results could affect their understanding of local weather processes and could be applied in other areas involving the extraction of wind energy, planned weather modifications, study of air pollution problems, and forecasting on a local scale.

The methods of dissemination of results were expected to be in the form of:

- presentations to various user groups,
- major presentations at national meetings which include the scientific communities and potential users,
- reports specifically oriented to the needs of users,
- extensive public information efforts including presentations on national television, on local television in St. Louis, radio programs, newspaper articles, and articles in major popular and scientific magazines, and
- scientific publications in user-related journals and atmospheric science journals.

Utilization Obtained

The METROMEX study is perhaps the most significant applied meteorological study in the inadvertant weather modification area. The results of the study have influenced users from a broad spectrum of disciplines. Utilization has been obtained by Federal agencies (Energy Research and Development Administration, Environmental Protection Agency, Federal Aviation Administration), State agencies (Illinois Division of Water Ways, Illinois EPA), local governmental agencies, business and industry (power companies, engineering firms, urban and regional planning groups, insurance industry), scientists and engineers (atmospheric scientists, ecologists, agriculturists), and the general public. The academic disciplines which are users of the METROMEX results include sociology, economics, hydrology, agriculture, ecology, and atmospheric science.

Dissemination of research results has been vigorous. Over 100 articles have been published in technical and professional journals. Technical presentations have been made to more than 30 groups. The general public has been informed of the project through local and national radio and television, national periodicals and local newspapers. A specific example of techniques for dissemination of results from METROMEX is a report to design-oriented data on rainfall, temperature, and winds, which will be published by the Illinois State Water Survey in 1976 for the aircraft industry, hydrologists, and urban health groups. In addition, seven Illinois State Water Survey (ISWS) reports on METROMEX have been published with 2,346 requests received beyond the 4,200 initially distributed. Over twenty-one METROMEX papers by ISWS alone have been published and 4,734 requests for reprints received beyond the 12,600 initially distributed. Over 50 papers have been published by the other participants.

The review of METROMEX findings and impacts on urban and suburban

hydrologic design will be published in a 1976 paper in the Water Resources Bulletin. The First National Conference on Inadvertent Weather Modifications will be hosted by the ISWS in Urbana, Illinois in September 1977. It will be co-sponsored by the American Society of Civil Engineers and the American Meteorological Society. The conference will give special emphasis to the METROMEX final results.

Much utilization is indirect in that it influences attitudes, decisions, and actions of the users and, in some cases, the drafting of regulations. Examples of utilization are diverse including energy development strategies, pollution control strategies, storm water and sewage systems design, flood control, rate setting in the insurance industry, design of water quality and quantity systems, and flood control. These are documented by the Illinois State Water Survey (ISWS) and are listed in Appendix A.

These data were compiled from careful records kept by Mr. Changnon and are just part of the vast amount of documentation available at ISWS to demonstrate utility of the program. Results of contacts made during this utilization case study are described below. These have generally substantiated and reinforced the findings by ISWS.

Mr. Ronald Dickeman, U.S. Army Corps of Engineers, St. Louis, Missouri, indicated that the Corps of Engineers used METROMEX rainfall data in a flood control design for the American Bottoms Area (essentially the City of East St. Louis, Illinois, and surrounding area). Their intent was to place a new pumping station for flood control in this region. The METROMEX data were used to determine the adequacy of the structure.

Mr. Lloyd Myers, U.S. Department of Agriculture, Berkeley, California, stated that he is preparing a report by the Department of Agriculture that

defines guidelines for future research in the western part of the United States. He plans to use the data and reports from METROMEX to identify areas of further research in inadvertent weather modifications that would have significance to the agriculture community.

Mr. Leo Helfand, Illinois EPA, Springfield, Illinois, indicated that the Planning Section in the Division of Water Pollution Control is using the rainfall data from METROMEX to study flow and overflow problems in sewer lines.

Mr. Patrick Lynch, Illinois EPA, Springfield, Illinois, stated that the Division of Air Pollution Control is interested in the air pollution data collected by METROMEX in and around the East St. Louis area. They are in the process of redefining the regulatory air pollution structure in Illinois. There is a particular emphasis in the East St. Louis, Illinois area which has significant air pollution problems.

Ms. Jacqueline Brimmer, Southwest Illinois Planning Commission, Collinsville, Illinois, reported that the METROMEX rainfall data are being used by the Commission in solving Collinsville's surface drainage problem. Particular emphasis is in the four-county area of Madison, Sinclair, Monroe, and Randolph, which is precisely downwind of St. Louis, Missouri. The rainfall data were used in a criteria manual, and aided in the establishment of design criteria for secondary drainage systems for the four-county area.

Mr. Don Ferris, City Engineer, Fairview Heights, Illinois (Fairview Heights is downwind of St. Louis, Missouri), indicated that the METROMEX rainfall data were helpful in a storm water study which is being prepared to help solve existing flood-related problems in the City of Fairview Heights.

Ms. Helen Parker, Missouri Botanical Gardens, St. Louis, Missouri, had a contract which was sponsored by the Electric Power Research Institute and Union

Electric of St. Louis, Missouri, on the state-of-the-art of knowledge on sulfur in the environment. The study scope was nationwide rather than local to St. Louis. However, the METROMEX results were an integral and important part of the information gathered on the subject. As a part of the overall study, a multi-disciplinary workshop on sulfur in the environment was held at the Missouri Botanical Gardens, and the METROMEX results were cited as a major data source for the subject in question.

Mr. Laurence Zensinger, East-West Gateway Coordinating Council, St. Louis, Missouri, indicated that the METROMEX data will be valuable in a 208 Regional Water Quality Management Plan being prepared for St. Louis. METROMEX data will be used in their water quality model.

Mr. Henry M. Reitz, Reitz and Jens, Inc., Clayton, Missouri, is a member of the Storm Water Technical Committee for the St. Louis Metro Study. This Committee is evaluating sewage designs and storm water input for the City. One goal of the Committee is to publish detailed rainfall and stream gauge data for the St. Louis metropolitan area. The METROMEX data will play an integral part in those publications.

Features

The principal factor that influences utilization is the effort of the Illinois State Water Survey--in particular, Mr. Stanley Changnon, in promoting utilization of the METROMEX results. The other Principal Investigators have influenced utilization, but Mr. Changnon has played the dual role of scientist and public relations representative for the METROMEX project. This is recognized by the other Principal Investigators and by the NSF/RANN Program Manager insomuch as they directed this case investigator to Mr. Changnon for overviews

of utilization. Mr. Changnon was instrumental in promoting utilization as endorsed by ISWS's 39 technical presentations and 22 presentations to the public, to a wide variety of potential users (see Appendices B and C), and in documenting utilization to demonstrate the utility of the program.

Conclusions

The most immediate and direct, but not unexpected, utilization of METROMEX results has been by State and local agencies in and around metropolitan St. Louis. The application of the results by Federal government agencies and the State governments, city governments, businesses, and industries has been indirect in the sense that these groups are aware of the METROMEX results, recognize their implications in other areas, and are concerned with translation of results into those areas. Direct application of METROMEX results by these users will be reconciled to a degree when procedures for translation of results are more explicit.

The significant utilization of the results of METROMEX is due to two factors: The first of these is the significance of the results themselves and their importance to potential users. The second is the strong and very effective efforts made by Mr. Changnon to promote the dissemination and utilization of the research results. Based on the utilization of METROMEX, the inclusion in other NSF/RANN-sponsored programs of a person who is specifically responsible for the promotion and dissemination of the results of that program could significantly and positively influence utilization.

References

1. Huff, F. A., and S. A. Changnon, 1960: An investigation of excessive rainfall amounts over an urban area. J. Geophys. Res., 65, 3759-3765.
2. Changnon, S. A., 1962a: Reply. J. Appl. Meteor., 1, 274-275.
3. _____, 1962b: Urban precipitation patterns. Air Over Cities, Cincinnati Public Health Service SEC Technical Report A62-5, 37-67.
4. _____, 1968a: Precipitation climatology of Lake Michigan Basin. Urbana, Illinois State Water Survey Bulletin 52, 46 pp.
5. _____, 1968b: The La Porte weather anomaly--fact or fiction? Bull. Amer. Meteor. Soc., 49, 4-11.
6. Fieg, A. M., 1968: An evaluation of the precipitation patterns over the metropolitan St. Louis area. Proc. First Nat. Conf. on Wea. Modif., Albany, 210-219.
7. Stout, G. E., 1962: Some observations of cloud initiations in industrial areas. Air Over Cities, Cincinnati, Public Health Service SEC Technical Report A62-5, 147-153.
8. Potter, J. G., 1961: Changes in seasonal snowfall in cities. Canadian Geographer, 5, 37-42.

Appendix A

Utilization of METROMEX Results or Data

Organization	Utilization
International	
Soviet Union Research Team	Cloud seeding from urban tracer information and advice on hail suppression evaluation techniques.
England (Queen Mary's College)	Information on how urban areas affect cumulus clouds and related analyses.
Italy (National Research Council)	Advice on developing a three-nation hail suppression project in Switzerland and analyses of hail data (3 visitors).
French Scientific Group	Techniques for analysis of surface hail data requested and furnished.
Canadian Forestry Service	Information on the impacts of urban-altered weather on trees and forested areas.
South Africa (Water Development Board)	Advice on techniques for evaluating inadvertent rainfall modification from hail suppression.
Switzerland (Zürich University)	Advice on use of radar and evaluation of hail data suppression program.
Brazil (Institute of Aeronautics)	Potential information on urban-altered rain for airport design.
Federal Agencies (United States)	
U.S. Army Corps of Engineers	Data and information on altered rain rates in the St. Louis area for re-design of runoff equations.

APPENDIX A. Utilization (continued)

Organization	Utilization
Federal Aviation Agency	Reconstruction of rainfall and radar echo conditions during a commercial airplane crash at St. Louis.
Housing & Urban Development (Secretary for Development & Research)	Frequency of urban temperature distributions for apartment designs.
Department of the Interior (Bureau of Reclamation)	Supplied computer programs and techniques for objective weather analysis for use in weather modification experiments.
Environmental Protection Agency	Description of the average temperature and wind conditions in the St. Louis region, and basic weather data for the St. Louis region, 1971-74.
Department of Commerce (National Oceanic and Atmospheric Administration)	Information on inadvertent weather modification findings for publications required by law, urban-produced changes in rainfall intensities for hydrologic design, and results and data for checking numerical models.
Energy Research & Development Administration (formerly AEC)	Description of weather observation methodologies for cities, and basic weather data at St. Louis.
National Science Foundation	Advice on weather modification programs and atmospheric sciences research.
Dept. of Agriculture Agricultural Research Service (ARS)	Quantified impacts of urban-altered precipitation on crop yields.
National Science Foundation National Hail Research Experiment (NHRE)	Advice on evaluation of hail suppression, surface hail instrumentation, and preparation of a review of the hail climate of North America.

APPENDIX A. Utilization (continued)

Organization	Utilization
State Agencies	
Illinois EPA	Effects on St. Louis of extremes of temperature and winds, and altered local heavy rain intensity in St. Louis that relates to water quality regulations for sewer plants.
Illinois Registration and Education Department	Status of weather modification and credentials for licensing companies.
California Department of Water Resources	Degree of change in rainfall intensity beyond cities.
South Dakota Weather Modification Commission	Recommendations on evaluation of statewide rain and hail data.
Illinois Institute of Aviation	Briefings and forecasts of severe weather.
State of Illinois	Development of an Illinois law to control and regulate weather modification.
University of Illinois	Weather forecasts for special university events and seminars about projects.
North Carolina State University and California State University	Reviews of urban-altered weather for application in research and teaching.
Dalhousie University	Ecological impacts from urban-altered weather.
Regional and Local Agencies and Organizations	
Southwest Illinois Planning Commission	Rainfall quality and quantity data for the St. Louis area for fulfilling Public Law 208 Water Plan Design.
East-West Gateway Coordinating Council	Rainfall quantity data relating to master plan for St. Louis region.

APPENDIX A. Utilization (continued)

Organization	Utilization
St. Louis County Health Department	Urban effects on temperature
Fairview Heights, Illinois	Rainfall design criteria for storm and sewer drainage codes.
St. Louis Botanical Gardens	Information on the urban-altered weather, and extremes of temperature in the St. Louis region.
DuPage Regional Planning Commission	Rainfall alterations at METROMEX transferability to the Chicago area.
Metropolitan Sewer District of St. Louis	An urban weather bibliography.
The Metropolitan Sanitary District of Chicago	Design data on shifts in urban rainfall maximum rates.
Business and Industry	
Colorado International Corp.	Evaluation of hail and tobacco loss data for project in South Africa.
Country Mutual Insurance Co.	Development of remote sensing techniques for aerial surveillance of crop-hail damage, general hailstorm information and data on surface hailstone characteristics for design of a hail simulator instrument.
Atmospherics, Inc.	Results on effectiveness of cloud base tracer releases at METROMEX as a simulation of cloud seeding, and evaluation of the company's hail suppression project in Texas, including testifying at a trial on the results of the project in Texas.
Crop-Hail Insurance Actuarial Assoc.	Systematic supplying of advice on the status of hail suppression, and furnishing of the results of hail studies which led to the development of a CHIAA-supported project to examine for long-term trends in hail losses and the relationship of hail loss in different states to gather information relative to setting future rates.

APPENDIX A. Utilization (continued)

Organization	Utilization
Hydrocomp, Inc.	Information on rainfall rate changes in the St. Louis region, and duplication of all rainfall data (1971-75) for heavy rains in the St. Louis area for use in water quality models.
Crop Insurance Research Bureau, Inc.	Annual reviews of the Illinois hail-storm situation, and a special evaluation of hail suppression techniques.
Nationwide Mutual Insurance Company of Ohio	Various values of altered hail east of major American cities and how they would relate to rate structures.
Hail Information Service of Florida	Information on the variations in surface hail losses found across distances ranging from 30 m to 20 km
Nestle Company	Urban alterations in heavy rainfall near their processing plant in the St. Louis area.
Green Giant Company	Recommendations on the use of weather modification in the areas where they contract with farmers to grow specialty crops.
Del Monte Corp.	Recommendations on the employment of rain modification and hail suppression for protecting their fruit and vegetable crops.
RAND Corp.	Information on the impacts, to agriculture and to hydrology, of urban-altered rainfall and severe storms.
Harza Engineering Company of Chicago	Changes in heavy rainfall intensities in urban areas.
Reitz and Jens Co. of St. Louis	Heavy rainfall rate data for the St. Louis region.
Zurheide-Herman Engineers of St. Louis	St. Louis rainfall rate alterations due to urban effects.

Appendix B

METROMEX Technical Presentation

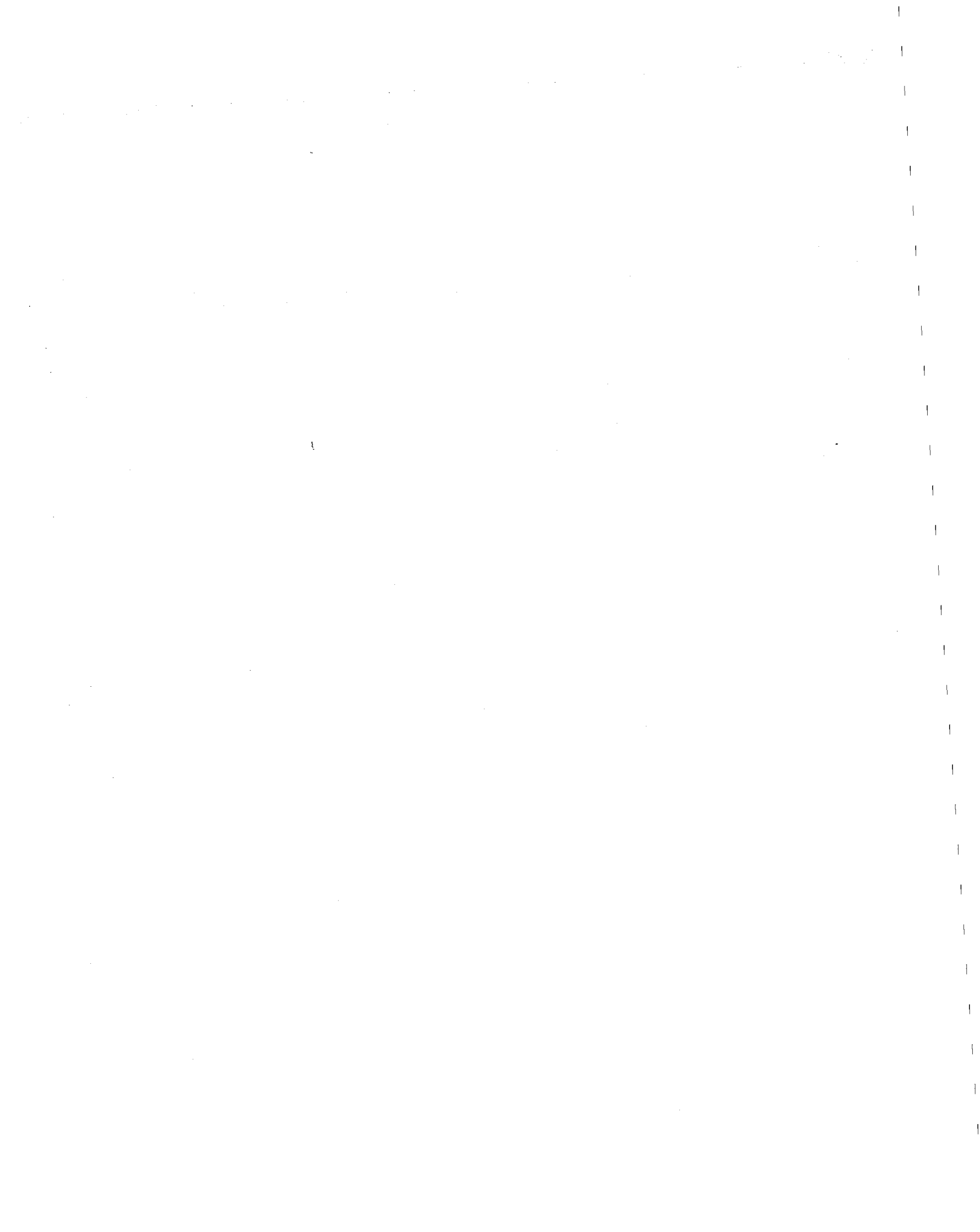
<u>Title</u>	<u>Site</u>	<u>Sponsor</u>	<u>Type</u>
<u>A Review of Urban Altered Weather</u>	St. Louis	Missouri Teacher's Assoc.	Lecture
<u>How St. Louis Makes Rain</u>	Ft. Collins, Colorado	Colo. State University	Seminar
<u>Actions Needed for Severe Weather</u>	Carbondale, Illinois	Southern Ill University	Panel Debate
<u>Comparison of Echo Statistics for Seeded and Non-seeded Storms in NHRE 1973</u>	Ft. Lauderdale	AMS	Talk
<u>A Short-Term Thunderstorm Forecast System: Step 1, Exploitation of the Surface Data</u>	Norman, Oklahoma	AMS	Talk
<u>Radar Studies of Severe Storms Observed on 3 April 1974 in Central Illinois</u>	Norman, Oklahoma	AMS	Talk
<u>On the Role of Strong Winds in the Damaging of Crops by Hail and Its Estimation with a Simple Instrument</u>	Norman, Oklahoma	AMS	Talk
<u>Radar-Thermodynamic Hail Day Determination</u>	Norman, Oklahoma	AMS	Talk
<u>Small-Scale Variability of Hail and Its Significance for Hail Prevention Experiments</u>	Ft. Lauderdale	AMS	Talk
<u>Design of a Hail Suppression Project for Illinois</u>	Ft. Lauderdale	AMS	Talk
<u>Weather Modification in Illinois</u>	Carbondale, Illinois	Southern Ill. Univ.	Talk
<u>The Design of a Hail Suppression Experiment in Illinois</u>	Alberta, Canada	AMS	Talk

Appendix B. (continued)

<u>Urban Effects on Hydrology</u>	Lebanon, Illinois	Ill. Water Works Opera- tors	Lecture
<u>Urban Climatology</u>	Collinsville, Illinois	Meet Ill. Geographical Society	Lecture
<u>Winds Over St. Louis</u>	Chicago, Illinois	Air Pollution Conference	Paper
<u>Urban Weather Anomalies</u>	New York	Annual Meet. of AAAS	Lecture
<u>Water and Agricultural Impacts</u>	Philadelphia, Pennsylvania	Earth Environ. and Resources Conf. (IEEE)	Talk
<u>Urban Weather Modification</u>	Philadelphia, Pennsylvania	Earth Environ. and Resources Conf. (IEEE)	Talk
<u>Overview of METROMEX Findings</u>	Rensselaerville, N. Y.	Inadvertent Weather Modi- fication (ASCE)	Workshop
<u>Research Needs on Inadvertent Modification</u>	Sioux Falls, South Dakota	N. Amer. Inter- state Weather Modification Council	Lecture
<u>Causes for Urban Rain</u>	Princeton, N. J.	Princeton Univ.	Seminar
<u>METROMEX Network Design</u>	Washington, D. C.	Conf. on Instru- mentation and Measurements (AMS)	Lecture
<u>METROMEX Findings</u>	Edwardsville, Illinois	Southern Ill. University	Seminar
<u>Low-Level Wind Design Data</u>	Asheville, N. C.	Workshop on Nat'l Wind Energy Pri- orities (NWS)	Paper
<u>Key METROMEX Findings</u>	Washington, D. C.	Washington AMS Chapter	Lecture
How Cities Produce Rain	DeKalb, Illinois	N. Ill. AMS Chapter	Seminar

Appendix B. (continued)

<u>Development of a Mesoscale Objective Analysis and Realtime Forecasting Capability</u>	Las Vegas, Nevada	AMS	Talk
<u>Radar Observations of Hail and Tornadic Storms on 3 April 1974</u>	Houston, Texas	AMS	Talk
<u>Heavy Rain Distributions by City Effects!</u>	Lexington, Kentucky	Nat'l Symp. Urban Hydrology (ASCE)	Talk
<u>Urban Effects on Heavy Rains</u>	Davis, Calif.	Nat'l Symp. on Hydrologic Modeling (AGU)	Talk
<u>Causes of Intense Urban Rains</u>	Davis, Calif.	Nat'l Symp. on Hydrologic Modeling (AGU)	Talk
<u>Methods of Digitizing Urban Rainfall</u>	Davis, Calif.	Nat'l Symp. on Hydrologic Modeling (AGU)	Talk
<u>Urban Rain Enhancement</u>	Syracuse, N. Y.	Air Pollution Control Assoc.	Lecture
<u>Terrain Effects on Rain</u>	Madison, Wisconsin	Annual Mid-western Meeting (AGU)	Talk
<u>Land Use Differences in Heating and Moisture</u>	Madison, Wisconsin	Annual Mid-west Meet (AGU)	Talk
<u>Analysis of Urban Produced Storms</u>	St. Louis, Missouri	Conf. on Weather Forecasting (AMS)	Paper
<u>Industrial Effects on Weather</u>	Danville, Illinois	Planning Grp. Conference	Seminar
<u>How Surface Effects Storms</u>	Norman, Oklahoma	Conf. on Severe Local Storms (AMS)	Talk
<u>Hydrometeorological Results</u>	Carbondale	Sou. Ill. Univ.	Seminar



Appendix C

Presentation of METROMEX Results to General Public

<u>Title</u>	<u>Site</u>	<u>Sponsor</u>
<u>Urban Rain and the Weather Machine</u>	Public Broadcasting System	BBC
<u>Suburban Weather Changes</u>	McCall's Magazine	McCall's
<u>Special Devices Measure Urban Rainfall</u>	Newsweek Magazine	
<u>METROMEX Findings and Their Ramifications for Other Research</u>	Washington	Nat'l. Advisory Committee on the Oceans and Atmosphere
<u>Federal Role in Weather Modification</u>	Washington	Environmental Research Committee
<u>Hail Suppression Possibilities</u>	Chicago	WMAQ-TV
<u>The Climate of Hail</u>	Champaign, Illinois	Illini Radio Network
<u>Status of Hail Suppression</u>	Chicago	CHIAA
<u>Hail Suppression Comes of Age</u>	Champaign, Illinois	Illini Radio Network
<u>Hail and Rain Modification</u>	Urbana, Illinois	WILL radio
<u>METROMEX Findings on Rainfall</u>	St. Louis	St. Louis Special Eng. Workshop
<u>METROMEX Rainfall Quality</u>	Collinsville	Southwestern Ill. Planning Commission
<u>Four Years of METROMEX</u>	St. Louis	AMS and Amer. Geophys. Union Chapters

Appendix C (continued)

<u>Relevant Rainfall Findings from METROMEX</u>	St. Louis	Interstate Plan- ning and Coordi- nating Group for PL 208 Program
<u>The Dimensions of METROMEX</u>	St. Louis	EPA-RAPS
<u>METROMEX Gets Ready for Final Year</u>	St. Louis	KSD - TV
<u>METROMEX Identifies the Guilty Parties</u>	St. Louis	KMOX - TV
<u>Various METROMEX Results on Rain, Temperature, Winds, Etc.</u>	Throughout Illinois	Illinois Radio Network (28 stations)
<u>Urban Altered Weather</u>	Wall Street Journal	
<u>How Cities Change the Weather</u>	St. Louis	Globe Democrat
<u>Man's Harmful Effects on the Weather</u>	Des. Moines	Register
<u>Witless Weather Mod</u>	Technology Review	MIT



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 38

THE TEXAS ENERGY ADVISORY COUNCIL RESEARCH PROJECT

UNIVERSITY OF HOUSTON

Case Investigator:

P. S. McMullan

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

Edward Azar

Political Science Department
University of North Carolina
Chapel Hill, North Carolina 27514

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

THE TEXAS ENERGY ADVISORY COUNCIL RESEARCH PROJECT

Introduction and Summary

In the spring of 1974, the State of Texas was awarded a National Science Foundation Research Applied to National Needs (NSF/RANN) grant to produce information on which to base public policy decisions, legislative recommendations, and research program content decisions for state policymakers on the issue of energy. It was sponsored by the NSF/RANN Office of Systems Integration and Analysis under a sub-program with the objective of providing funds to upgrade the quality of state and regional evaluations of their responses to the energy crisis. The Texas grant was the first and most comprehensive of the several grants under this sub-program.

The impetus for the Texas grant was the energy crisis, in general, and the Arab oil embargo of 1973, in particular. In response to a legislative resolution, Governor Dolph Briscoe of Texas established the Governor's Energy Advisory Council (GEAC) by Executive order. The Council was directed to analyze energy supply and demand and to make recommendations on state energy policy, actions necessary to implement this policy, an energy research and development program, and on mechanisms for ongoing energy policy planning. Existing energy policymaking activities of the State would be drawn together by the Council's activities. The Council staff began its activities in the fall of 1973.

After conferences and preliminary research efforts in the summer and fall of 1973, a draft GEAC program was prepared and approved by the Council

in January 1974. The financial package of \$1,219,500 included \$534,500 from NSF/RANN, with the first grant of \$399,000 being awarded by NSF to the State of Texas on May 15, 1974. NSF/RANN project information is detailed in Table 38-1.

The GEAC was organized with Lieutenant Governor William P. Hobby as Chairman, and a council membership which included seven key elected state officials, ten appointed officials, five individuals from universities and public interest groups, and twelve industry representatives. Dr. A. E. Dukler, University of Houston, was appointed to serve as Executive Director of the GEAC program and Principal Investigator for the NSF/RANN grant. The research program consisted of two basic parts: (1) a program core that included 37 projects, and (2) three coordinated studies of somewhat larger scope. State agencies, universities, and one private firm participated in the 37 projects and three studies. The NSF Program Manager reports that the GEAC program was extremely well planned and coordinated so as to produce timely results. The program provided working papers and an interim report on Texas energy resources within two months after award of the NSF/RANN grant. These provided important information for the Council, as it debated energy policy with the Governor, State Legislature, and Federal agencies.

By March of 1975, GEAC program participants had completed and published 40 reports documenting the Supply and Demand Program, Environmental and Social Program, New Technology Program, Legal and Regulatory Program, and five special projects. A number of bills introduced into the Legislature had been passed. One of these established the GEAC as an institution of State government. Others established a Utilities Commission in Texas for the first time, initiated an energy conservation program, committed the State to mass transit, and clarified state authority in geothermal production. Bills to create an energy

Table 38-1
PROJECT INFORMATION

Project Title	Program of Research for Public Policy Planning in Texas	Grant/Contract No. G144085
RANN Program Manager		RANN Program Area
Dr. Bruce Smith		Systems Integration and Analysis
Principal Investigator(s)		Schedule
Dr. A. E. Dukler		Start: May 15, 1974 End: May 1975
Institution		Funding
Governor's Energy Advisory Council State of Texas		FY 74 \$399,000 NSF: FY 75 \$135,000 Other: State Agencies \$345,000 Universities \$230,000 Private Firms \$ 60,000
Contributors/Collaborators:	The numerous contributors are listed in Exhibit 2	
User Advisory Committee:	The Governor's Energy Advisory Council and its Subcommittees were the users.	
Precursor Activities:	Creation of the State of Texas Energy Advisory Council.	

development fund and to conserve natural gas failed to pass, but are still under active consideration.

Within the State of Texas, products of the GEAC program have achieved a high level of utilization. Because of the effective organization and leadership of the program, information exchange between researchers has been very high. State agency personnel who served as both investigators and users further expanded the utilization of research results. Active participation

by key policymakers on the Executive Committee insured that policies of the Texas commissions and agencies most concerned with energy issues were influenced by the program. Other State agencies and private firms were represented on the Council and its committees. Actions by several energy-related firms to develop alternative energy sources can be traced to their participation on the committees. The general public was given frequent opportunities to have input through public meetings, and public information was provided routinely.

Reports from the GEAC program have been widely distributed outside Texas by the National Governors' Conference and by the GEAC staff. As of June 1975, the reports had been received by well over 100 Federal and State energy agencies, research institutions, and private firms outside Texas.

The organization of the program within State government and the active participation of State agencies were major factors in achieving utilization. The pressing nature of the energy crisis insured that the research and the Council would have the attention of the executive and legislative branches. Capable management of the program insured that there was an exchange of information among its projects. Workshops were organized for industry and the public so that interested users would have access to the research, and the Advisory Committee was composed of representatives of industrial firms and citizen groups to help focus the effort on pressing problems. Finally, the present GEAC staff reports that NSF allowed the State considerable flexibility in using grant funds. They felt this enabled the State to get maximum benefit from grant funds by extracting policy related findings from more academically oriented research.

It is concluded that the Texas Governor's Energy Advisory Council Program is a highly utilized program with significant NSF/RANN grant support. Its findings have had a significant influence on Texas energy policy and planning.

The program is being continued without NSF funding. This model for cooperation between academic researchers, State agencies, and the private sector is one that should be considered for adoption by other state governments.

The GEAC program provides an example of one manner in which research support can be applied to address a state's posture in the energy policy planning arena. States with significant actual or potential energy supply capabilities will find the example of greatest value. Much of the specific research is unique to Texas, but the methods employed and some of the findings in the new technology area have found interested public and private users in Washington and in many states.

Research Description

The State of Texas produces almost 40 percent of the oil and gas produced in the United States and this provides over 25 percent of all the fossil fuel energy in this country. The State also leads all other states by a wide margin in the consumption of energy. Because of its position as both producer and consumer of energy, Texas is greatly influenced by energy policies of the United States, and the Nation is affected by energy policies of the State of Texas. Almost one out of every ten Texans is directly dependent on energy-supplying industries for his or her livelihood, and more than 18 percent of revenue for State government operations is derived from these same sources.

At the height of the energy crisis in the spring of 1973, the State of Texas recognized a pressing need to organize a response to the crisis. The 63rd Session of the Texas Legislature passed a resolution requesting that Governor Dolph Briscoe establish a council and direct it to coordinate the

State's approach to energy related problems. A Governor's Energy Advisory Council (GEAC) was established by Executive order on May 10, 1973. The Council was directed to perform such analyses and research as were necessary to determine the options which were open to the State of Texas in setting and implementing its energy policy. The primary concern of the Governor and the Legislature was that the energy crisis could have both a short-term and long-term negative effect on the economy of Texas and the well-being of its citizens. It was recognized that the Federal government, private industry, and the Organization of Petroleum Exporting Countries had more power to influence the future of energy than did the State of Texas. However, the State has some control over productive lands through ownership, additional control through legislation and regulation, and a responsibility to be a leader among states in influencing the energy policy of the United States.

The inception of the program was a matter of Statewide involvement. The program of the Council was developed through public hearings throughout the State, circulation of draft plans through State offices concerned with energy, meetings with the relevant legislative committees, and reviews of abstracts and research reports in the energy field to find qualified personnel and institutions. On January 21, 1974, the staff presented a recommended program to the full Council. The staff had obtained commitments from individuals who were needed for the program and recommended that Federal funding be obtained to assist in financing the study. The principal investigator and program manager both report attempts to involve both NSF and the Federal Energy Office in the grant. However, the program manager did not obtain FEO financial support and the principal investigator said there was no interest shown in the project by FEO.

Because of the national need for energy policy, and the importance of

Texas energy to the Nation, NSF/RANN was very much involved in the evolution of the GEAC program. Dr. Thomas Sparrow, Program Manager during the formulation of the project, became involved in response to a grant proposal for energy policy research from the University of Texas at Austin. This initial proposal was to support the work of the Council, but it had not been coordinated with the Council or its staff. With Dr. Sparrow's assistance, the newly appointed Executive Director prepared a revised proposal that had the user community and the research community coordinated in a single program. This revised proposal resulted in the first grant awarded to Texas by NSF/RANN to support the GEAC.

In the finally evolved program, Lieutenant Governor W. P. Hobby was designated as Chairman of the Council, Dr. A. E. Dukler was retained as Executive Director, and 34 members of the Council were appointed. The Council members comprised seven key elected officials of the State, five individuals from university and public interest groups, and twelve individuals from various segments of industry. All members of the Council served on the Executive Committee or on one of four other committees. The four sub-programs for which these latter committees provided direction were the four research and planning areas into which all activities of the GEAC were organized. The committees were:

- Program Committee on Supply and Demand (S/D)
- Program Committee on Environmental and Social Aspects (E/S)
- Program Committee on Legal and Regulatory Policy (L/R)
- Program Committee on New Technology (N/T)

Figure 38-1 shows the management structure, the four-program core, and the three coordinated projects to be conducted--project A at the University of Texas in Austin and the other two at Texas A&M University.

A number of universities, state agencies, and private firms participated

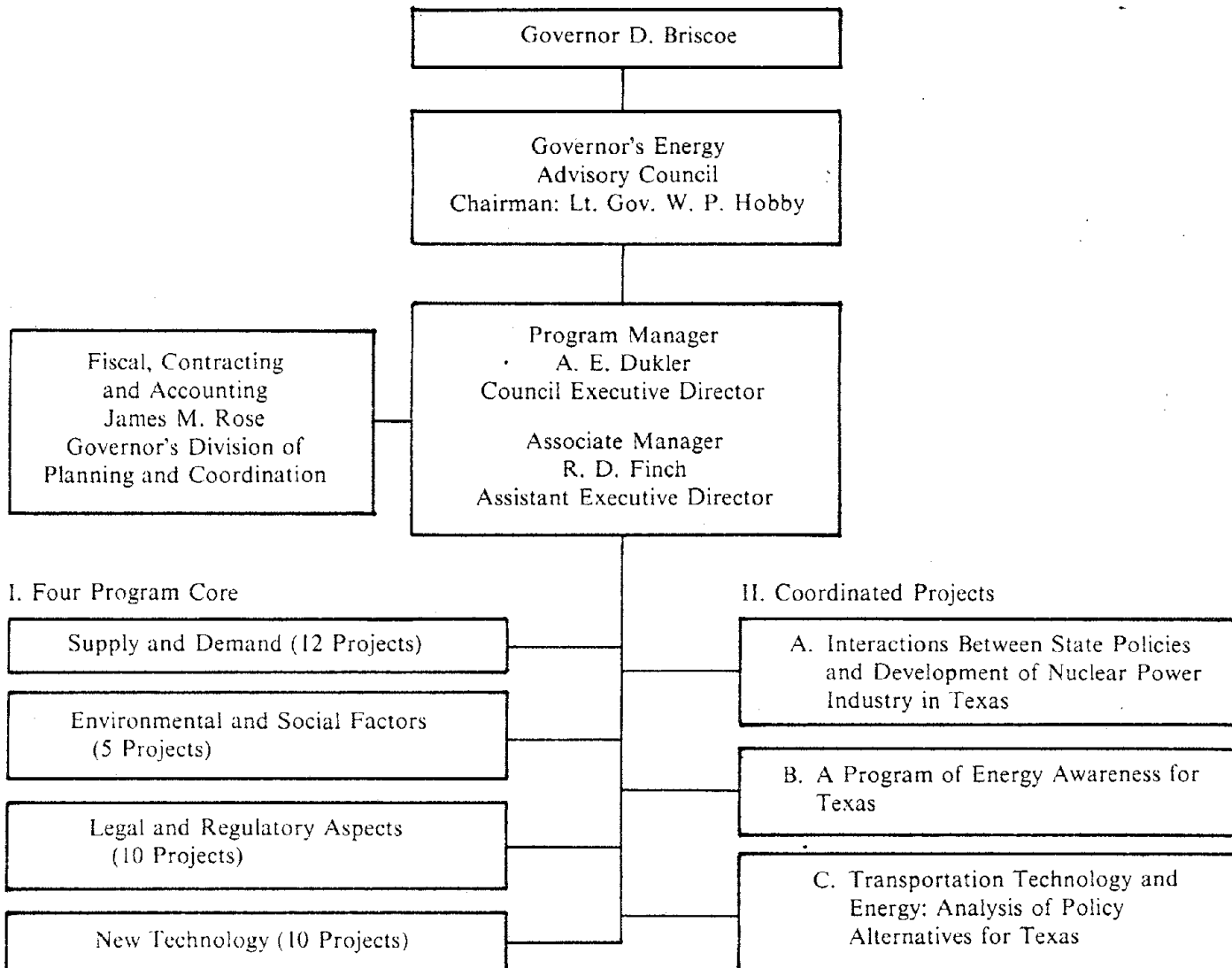


Figure 38-1. Program Management

in the study. These organizations, their research subjects, and the individuals involved are shown in Appendix A. The appendix listing shows that the GEAC program was broad in scope and coverage.*

Utilization of the project began immediately with the supplying of background material for the Council and the preparation of policy action options. A summary of background information on Texas Energy Resources was presented as a staff report to the Council in July 1974 and the GEAC had adopted Policy Action Option Recommendations by January 10, 1975. The recommended options included:

- Geothermal Production Act - clarifying State authority and responsibility for geothermal energy development.
- Natural Gas Conservation Act - relating to extraction and transmission of ethane and propane gas and the minimization of use of natural gas as a boiler fuel.
- Energy Efficiency Labeling Act - authorizing energy efficiency labeling enforcement by the Agriculture Department.
- Energy Policy Planning Act - establishing the GEAC by an act of the Texas Legislature rather than through Executive order.
- Energy Development Fund Act - providing State funds for new energy source development.
- Utilities Regulation Act - providing State regulation of utilities for the first time in Texas.
- Environmental and Energy Procedures Act - requiring regulatory agencies to give precedence to energy-producing projects and requiring coordination of agencies to ensure that environmental

* All research reports from the GEAC program are listed in Appendix B.

considerations are part of the decision-making process in the production of energy.

- . Energy Conservation Buildings Act - directing that building codes include energy use criteria.
- . Mass Transit Act - committing the State to urban mass transit.
- . Encourage Advanced Recovery of Oil - suggesting that the Governor ask the Federal Energy Administration to remove the two-tiered pricing system and encourage advanced recovery from old reservoirs.

From these ten recommendations, eight bills were drafted by GEAC and legislative staff and submitted to the 1975 Legislature. Bills related to the establishment of the Governor's Energy Advisory Council, the development of geothermal energy, mass transit, energy conservation (to begin in State buildings) and the establishment of a Utility Commission were passed. The Energy Development Fund Act, and the Natural Gas Conservation Act were unsuccessful, but are being modified for re-submission in 1977, which is the next session of the Legislature. The Energy Efficiency Labeling Act was also unsuccessful.

The individual research projects were drawn together in a coordinated study entitled Texas Energy Scenarios (March 1975) which made the following conclusions:*

1. *Impact of National Import Policy on Texas*

There are presently many uncertainties about Federal Policy which need to be resolved before State planning can be truly effective. However, it is clear that with a reduction or curtailment of oil imports by regulation of a quota, the Texas refining industry will decline. In order to maintain the State's economic growth and employment, other industries must grow or new industries be introduced.

*

All research reports from the GEAC program are listed in Appendix B.

2. *Effects of Market Forces*

With a "floor" price or quota on national imports and deregulation of domestic prices, market forces could bring about a new economic equilibrium in the national market by 1985. Increase in domestic supply would take place and some energy conservation through the use of known technology. Texas oil and gas production would be greater than under present regulations, but would still be on a downward trend by the year 2000.

3. *Conservation Potential*

Since energy conservation brought about by market forces is not additive to that resulting from government regulation, such regulation should be aimed at those areas not readily influenced by market forces by promoting such measures as efficient government energy use, energy efficient building codes, mass transit and energy efficient transportation (e.g., waterways, railroads).

4. *New Technology*

In the long term, new supply technologies will be necessary for Texas to replace the employment shortfall in the oil and gas industry, to meet Texas' own energy demand, and to enable the State to continue as an energy supplier to the Nation. Because of high risk and high development costs, Federal and State Government must support research and development of these new technologies. Energy technologies of significance to Texas are: secondary and tertiary recovery of oil and gas, solar, geothermal, in-situ lignite gasification, solid waste and wind.

5. *Continued Growth of Industry and Agriculture*

Industry and agriculture have grown in the State relying on ready availability of oil and gas. With limitations on national imports, the State's policy should be to ensure availability of the State's resources in Texas. The petrochemical industry, in particular, must be assured a supply of oil and gas for use as feedstock, particularly for fertilizer production, since there is no feasible substitute at present.

6. *Environmental Issues*

a. The air control studies indicate that the anticipated increase in use of solid and liquid fuels will lead to large increases in the emission of sulphur dioxide and particulate matter into the atmosphere over Texas. However, it appears that the existing ambient air quality standards can be met even with these increased emissions. In those instances where the estimated maximum air pollution levels will not approach ambient air standards, it may be sound to consider on a case by case basis the use of variable or selected standards.

b. The best practical technology and best available technology requirements projected by the Environmental Protection Agency (EPA) for water

quality control can be met with reasonable cost for the quantities of fuels expected to be used in Texas.

c. The total land requirements to meet energy development in Texas are modest and probably acceptable. Specific land use problems such as strip mining and power plant siting need to be monitored and probably given some guidance at the state level.

7. *Social Impact*

a. Because each type of policy action impacts various occupational and social categories in a different manner, the State should undertake a program of public awareness to ensure that the public is kept aware and informed of developing trends.

b. Because of the public suspicion regarding energy matters, there is a need for a responsive mechanism whereby the voice of the public can be heard in the formulation of plans for energy development and conservation.

c. Voluntary conservation measures will not be as effective as economic measures or mandatory controls. Incentives will generally be more popular than deprivation schemes.

d. There will probably be a shortage of engineering and technical manpower in the State if the various measures to increase supply and reduce demand are put into effect.

8. *Improvement of State Management Aids*

There are a number of uncertainties in the present studies; consequently, there is a need to stay aware of developing trends, and continue to update econometric forecasts to anticipate needs for energy, capital, manpower, and research and development. Shifts in public attitudes on energy matters will also require continuous monitoring.

Following the completion of the NSF-supported research projects, summaries and completed studies listed in the bibliography were distributed widely throughout the United States, as will be discussed under "Utilization Obtained." The Executive Director and Assistant Executive Director returned to their academic duties at the University of Houston and replacements were named for the reorganized Council staff. Researchers from the participating Universities continued their special research interests under funding from other Federal and State agencies and private firms. The GEAC was transformed from a special

Advisory Council to the Governor into an established institution of Texas State Government.

Following the passing of the Energy Policy Planning Act of 1975, the GEAC became authorized and funded by the Legislature and was reorganized in accordance with its new authority and responsibilities. The Governor became Chairman and the Lieutenant Governor, Vice-Chairman. The legislated duties of the Council are to:

- develop and maintain an energy data base system and an econometric model of the State;
- analyze manpower needs for anticipated and desired developments in the structure of the Texas economy due to energy developments;
- analyze technological developments;
- maintain an awareness of all energy related research, to promote information exchange and coordination;
- monitor and review existing and proposed actions and policies of all State and Federal agencies to determine the energy impact, and recommend possible alternatives more consistent with the State energy policy; and
- recommend legislation and Executive action to foster the development of increased energy supplies, more efficient energy systems, and increased conservation of energy.

The Act also provides that the GEAC administer a public awareness program for both general and special audiences.

The new Executive Director of the GEAC staff is Alvin C. Askew, and Joe E. Ventura is the Associate Executive Director. Both of these individuals participate full time in these capacities. The Program Operations Division

is now actively pursuing a public information program for the general public, an educational program in the education community, and a business and industry program to inform the State's business and industry communities of the current and projected energy picture. The Forecasting and Policy Analysis Division's major functions consist of: (1) the design and construction of an energy data base, (2) maintenance of an econometric model, (3) assessment of the state-of-the-art from "new" technologies, (4) the analysis of specific policy proposals, and (5) the writing of an energy policy paper. The Division Director reports that the Division has and will continue to be called on for input into Legislative Committee hearings and for the preparation of testimony for agency public hearings.

In addition to the reports produced and the bills passed, the present GEAC staff highlights the following activities which resulted from the recommendations of the GEAC program:

- The (first) Annual Texas Energy Forecast Conference in March 1976 was attended by about 250 persons from State agencies, universities, utilities, and other businesses and industries.
- The State Board of Control is now performing tests and writing specifications for State purchases based on life cycle costs (including energy) rather than initial costs.
- Energy conservation programs are being developed separately in four Texas cities with GEAC aid and funding.
- With FEA support, a study is underway of energy conservation and cost effectiveness to retrofit buildings in the present State Government Complex in Austin.

GEAC is currently preparing legislative recommendations for the next (1977) Legislature on the appropriate functions of the new Utilities

Commission. They are also updating the NSF-supported research studies in the areas of Supply/Demand and New Technology.

Utilization Objectives

As stated in the proposal to NSF/RANN, the project's objectives were to produce information on which to base public policy decisions, legislative recommendations, and research program content decisions for Texas State policy-makers. The utilization objectives were also stated in the proposal as follows:

"In-State Utilization: Each project will provide information in the form of monthly progress letters, an interim report, verbal briefings and a final report. Customers for this information will be the investigators of related or dependent projects, the members of the Council staff, the Council Executive Committee, the Council committees and the full Council, as appropriate. Monthly meetings of the Executive Committee will be held at which time summary briefings of progress will be made by the staff. In certain cases, investigators will be asked to present interim results to the Executive Committee. Council program committees will be asked to review project interim reports of their program area. Final reports will be distributed to all members of the Council. Of course, testimony before the appropriate legislative committees will provide widespread exposure to the project of this work.

"In addition to this Council- and Legislature-wide scheme of communication and utilization, Project II-B, A Program of Energy Awareness of Texas, has the task of communicating the results of the work of the Council and its projects to all interested segments of the Texas community. As discussed in that project description, there will be established a series of regional workshops where results of the work of the Council are presented to various segments of the industrial community and public. A bulletin reporting on this work of the Council will be initiated. Public service broadcasting efforts will also be undertaken.

"It should be noted that the program is "self-utilizing" to a great extent, since the grant administration to a large extent is in the hands of the users of the research."

"Out of State Utilization: The results of the work of the Council program and its individual projects will be made available to other states through the offices of the National Governors' Conference Energy Project. This will be done in two ways.

a. Copies of final project reports will be made available to Mr. Rovner's

office for distribution to other states, and to NSF for national distribution.

- b. The Executive Director will cooperate with the NGC Energy Project Director to arrange and conduct briefings on progress of projects in this program which may be of significance to other states."

Utilization Obtained

As shown by the utilization objectives above, it was intended that the program would be widely utilized throughout its performance period within the State of Texas and that its final products would be widely distributed outside the State. These objectives were all met.

In examining and evaluating the utilization that was obtained and in reviewing the utilization objectives, a broad and diverse group of users was identified. The first user group comprised the GEAC program participants who exchanged findings among themselves. Both researchers and policymakers were included in this first group. Next in importance are the public agencies and private firms in Texas who have used the products of the research. Finally, there are users outside Texas. The following discussion will address each of these groups in order.

The flow of interim and final products within and between participants in the program is emphasized in the utilization objectives and by the Principal Investigator, Dr. Dukler. If the program participation had been restricted to academic researchers, this point might be of less importance to RANN's utilization objectives. However, the GEAC staff provided daily input to key policy positions within Texas State Government, and the participating committees of the Council included key governmental officials and significant representation of energy-related industries. Many of the significant findings were

instrumental in policy decisions and drafting of legislation long before the preparation of final reports.

Dr. Dukler points to the Executive Committee as a singularly important avenue for utilization. This Committee was chaired by Lieutenant Governor W. P. Hobby and Dr. Dukler pointed out that the Lieutenant Governor always chaired meetings of the Committee. The remaining members of the Executive Committee were:

Mr. Charles Purnell, Governor's Executive Assistant
The Honorable John Hill, Attorney General
The Honorable Bob Armstrong, Commissioner of General Land Office
The Honorable J. C. Langdon, Chairman, Railroad Commission
The Honorable J. C. White, Commissioner of the Department of Agriculture
Senator Max Sherman, Chairman, Senate Natural Resources Committee
The Honorable Jon Newton, Chairman, House Energy Crisis Committee
Dr. A. E. Dukler, Executive Director.

These were the legislative and executive officials most able to influence policy, regulations, and legislation related to energy in Texas. A statement to the effect that this was a first time for Texas elected officials to get together on such a concerted position was made during a Council meeting by Commissioner of Agriculture John C. White, who has served as Commissioner for 20 years.

Although the Executive Committee was much more involved in the continuous activities of the GEAC, members of other committees were also significantly involved. Private energy-related firms were represented at meetings by the heads of these companies. They contributed to the research design and carried significant findings back to their corporations. For example, Houston Light and Power Company's representative was initially negative toward the potential of solar energy. The company has since invested in solar energy development after the demonstration of its feasibility to the Council.

As another example of GEAC influence on industry, Dr. Dukler stated that the Shell Oil Company initially rejected the possibility of lignite as a

feasible source of energy in Texas. The Committee ordered the staff to resolve the conflict of information presented by Shell and GEAC researchers. It was determined that Shell's information was an out-of-date report supplied to them by the U.S. Geological Survey. More recent information from the Texas Bureau of Economic Geography was supplied to Shell, and Shell has now initiated a program to develop energy from Texas lignite.

Utilization such as that illustrated by the Houston Light and Power Company and the Shell Oil Company was initiated both by corporation memberships on the Council and open publications. Reports on the research and findings were distributed to energy related firms in the State. Summaries were distributed to almost every company in the State, and over 130 full reports were requested. Frequent requests for additional information were honored by the staff. The process was thus open to all firms and not restricted to firms represented on committees. Results of the completed program and the programs of the reorganized GEAC continue to be dissipated 10 times each year through the GEAC supported newsletter, "Texas Energy," published by Texas A&M University.

There is evidence that the Texas Legislature has accepted the importance of research and its use in energy policy setting. This is demonstrated by the Energy Policy Planning Act of 1975 which requires, "...econometric modeling of the state...analyzing technological development"...and... "maintaining an awareness of all energy related research..." Also, Representative Bill Clayton, Speaker of the Texas House of Representatives, told the case investigator that economic models used in the research are often used by the Legislature in its deliberations and that the Legislature is becoming increasingly aware of the need for a scientific base such as that which the GEAC program and other NSF/RANN studies can provide. Dr. Herbert Grubb is a

state agency investigator in the Supply and Demand core program and a supplier of policy studies to the Governor and the Legislature. He believes that the co-mingling of users and researchers in NSF/RANN studies has contributed significantly to the climate of acceptance in Texas of the researcher's role in policy decisions. Dr. Grubb participated in a similarly organized study of Coastal Zone Management supported by NSF/RANN. Dr. Grubb said the two studies were similar in utilization procedures, but that the GEAC program received much greater attention and utilization because of the urgency of the energy crisis.

Some of the Program's urgency has dissipated since the adjournment of the Legislative session of 1975, and this is reflected in current GEAC plans. Interviews were held with Mr. Joe Ventura, Associate Executive Director of GEAC; and with Dr. Milton L. Holloway, Division Director; Kerry Helgren, Legislative Liaison; and Robert Davis, Staff Member, of the Forecasting and Policy Analysis Division. These GEAC staff supplied the information about current GEAC plans and activities which was presented in "Research Description." As staff to the reorganized GEAC, they are prime continuing users of the products of the NSF/RANN supported research programs. Their comments agree with others interviewed that the utilization of the NSF/RANN supported program was enhanced because:

1. The program was not purely academic: the Council had a number of industrial and citizen-interest persons as members and advisors.
2. The final project reports provided building blocks for the present GEAC programs and represent a fairly good starting place.
3. The personal knowledge which the present staff and Council has of other workers and researchers in the energy area--their interests, capabilities, and personalities--makes it easier to go on to new activities in the present. The program "got State Government and University persons talking to each other."

4. NSF allowed the State considerable flexibility in developing the project, allowing the State to get maximum benefit from program funds from other less flexible sources.

Without exception, those contacted within Texas agreed that the program had accomplished its utilization objectives. Dr. Bruce Smith, NSF Program Manager, agrees with this assessment and credits success largely to the program structure and the Principal Investigator's management ability. He also agrees with the assessment of the present GEAC staff and Dr. Grubb that NSF/RANN support was essential to assure a research orientation to the program.

Those outside Texas who have followed the development of the program include Dr. Jules J. Duga of Battelle Memorial Institute, and Dr. James Baroff of the National Governors Conference. Under an NSF/RANN grant, Dr. Duga reviewed the energy policy research programs supported by NSF in California, New York City, Texas, Vermont, and Wisconsin. He reports that only in Texas was the analysis of energy policy done both within the policymakers' organization and with substantial research resources. He states that analysis in this context "tends to be relevant and acceptable." He said that the Texas GEAC program was a good example of how technology can feed into the legislative process. He does not believe that the individual research results and staff reports are used outside Texas to a major degree, but he believes that the concept of organization to increase the use of technology by policymakers has validity in many other states.

Dr. James H. Baroff of the National Governors Conference Energy Program provides a reference service to the states for energy-policy related studies. He does not know whether State agencies made extensive use of GEAC products in their own planning, but he stated that there was great interest in obtaining the documents. As Science Advisor to the energy program, Dr. Baroff received numerous telephone requests which were honored without being recorded.

Written requests were received from the Appalachian Regional Commission, Southern Interstate Nuclear Board, Energy Research and Development Administration, Mississippi Geological Survey, U.S. Geological Survey, Ohio Energy Commission, and the New Jersey Energy Office. These are just a few examples of the several hundred out-of-state users receiving the reports.

Copies of the full report were sent without request to the principal energy agency in each of the 50 states. An exact count of additional requests for reports by out-of-state users is not available, but a GEAC report shows that 35 energy firms, 34 Federal agencies, 32 State agencies, 26 Universities and 15 others had requested copies by June 4, 1975. Within Texas, reports were requested and distributed by June 4, 1975 to 128 users within energy firms, 60 university users, 32 State agency users, and 52 requests from private citizens were honored.

Dr. Dukler estimated that as of July 1976, the project team had responded to over 700 requests from both within and outside Texas for parts or all of the final report.

FEATURES

The features that influenced utilization were listed throughout this case study. In summary, the key features appear to be:*

- The seriousness of the energy issue was widely perceived in Texas.
- There was a strong consensus on priorities in Texas.
- The policymaking organization was integrated with the analytical

* Categories used here are based in part upon Figure 1, "Characterizing Energy Policymaking in Five States": Jules J. Duga, et al., Energy: The Policy Planning Framework in State Governments, Vol. I, Battelle, Columbus, Ohio, April 1976.

organization.

- The process was open to all participants and the organization encouraged participation in analysis and policymaking.
- There was strong leadership of the program by the Executive Director and strong support from key officials.
- NSF/RANN support, flexibility, and participation in program design made it possible to carry out a technologically sound program.

The strengths of the program are much the same as the features that influenced successful utilization in Texas. The weakness in the approach is that the concentration of human energy on the problems and the crisis atmosphere can not be maintained indefinitely. After the program had met its objectives for impact upon the Legislative Session of 1975, there was a lapse in continuity of about six months when the Executive Director and Assistant Executive Director returned to academic duties at Houston.

The GEAC is now State funded and institutionalized, less free from political pressure, reduced in resources, and oriented toward less intensive research and more routine programs. The GEAC now has the opportunity to fill in research and information gaps, as recommended by the NSF supported GEAC program, and to "fine-tune" the legislative recommendations which were rejected by the 1975 Legislature. Since the legislature did not meet in 1976, the GEAC pace can be expected to quicken as the 1977 Legislative Session approaches--not only to support legislative proposals, but also to justify continued and/or increased levels of funding for GEAC.

Conclusions

The program is an excellent model for the use of NSF/RANN resources to encourage the utilization of technology in state policy decisions. The model has worked successfully in a state in which policymaking is highly diffuse, and it should work with even less difficulty in more centralized state governments. However, it must be observed that the organization model may not be as effective without the existence of a widely perceived crisis issue and the availability of a very capable Principal Investigator.

The openness of both the analytical process and the policymaking process to private firms and individuals is also concluded to be an important factor in utilization beyond policymaking circles. The program was successful in involving the public, and this was important to the successful legislative program and to the future of private energy development in Texas.

Finally, the GEAC program was very highly utilized within Texas and generated a significant amount of interest outside the State.

Appendix A

Program Core Research Subjects,
Investigators and Organizations

APPENDIX A. Program Core Research Subjects, Investigators, and Organizations

SUBJECT(abbreviated)	INVESTIGATORS	ORGANIZATION
(Core Program A. - Supply and Demand S/D)		
S/D in Texas, 1948-1974	Dr. H. Grubb	Governor's Office of Information Services
Demand in Texas, 1975-2000	Dr. H. Grubb	Governor's Office of Information Services
Impact on Texas Economy	Dr. H. Grubb	Governor's Office of Information Services
Elasticity of Energy Demand	Dr. T. Thompson	University of Houston
Pricing vs. Secondary/Supplemental Recovery	R. King	Staff
Importing Fuels and Petrochemicals	S. Bridges J. Sammon	Texas Transportation Institute, Texas A&M University
Conservation/Buildings	Dean R. D. Reed	College of Architecture, Texas A&M University
Conservation/Transportation	Dr. Jack Keese	Texas Transportation Institute, Texas A&M University
Conservation/Industry	Dr. H. W. Prengle, Jr.	University of Houston Chemical Engineering Department
Energy Data Bank	Dr. J. Zuckerman Dr. H. Grubb	University of Houston Energy Institute Governor's Office of Information Services
Conservation/Agriculture	Dr. C. G. Coble Dr. W. A. LePori	Texas Agricultural Experimental Station

SUBJECT (abbreviated)	INVESTIGATORS	ORGANIZATION
	(Core Program B. - Environmental & Social Aspects E/S)	
Impact on Land Use	Dr. W. F. McFarland	Texas Transportation Institute, Texas A&M University
Impact on Air Quality	Dr. W. G. Adkins	Texas Real Estate Research Center
Impact on Water Quality	Dr. G. A. Rohlich	Texas Air Control Board
Standards for Pollution Control		University of Texas/Austin
Sociological Dimensions	Dr. D. Gottlieb	Texas Air Control Board
		University of Houston
	(Core Program C. - Legal & Regulatory Aspects L/R)	
Existing Law in Texas	Joe Bill Watkins Linward Shivers	Attorney General of Texas Oil & Gas Division, Office of the Attorney General
	Rex White	Transportation Division, Office of the Attorney General
	John Gangstad	Office of the Attorney General
	Prof. William W. Gibson	School of Law, University of Texas
	Ron Sandberg	Office of the Attorney General
	John Birkeibach	
Legal Information	Joe Bill Watkins Daniel R. Barney	Attorney General of Texas Office of the Attorney General
Legal Aspects of Conservation	Philip K. Maxwell	Environmental Protection Division, Office of the Attorney General Office of the Attorney General
	Marc Wiegand Joyce Carpenter	
Legal Aspects of Allocation	Prof. William W. Gibson Edward Hawkins	School of Law, University of Texas Office of Attorney General
Legal Aspects of State-ownership	Prof. Ernest Smith Jep Hill	School of Law, University of Texas General Land Office of Texas
Tax and Other Incentives	Rick Harrison M. Johnson	Taxation Division, Office of the Attorney General University of Houston

SUBJECT (abbreviated)	INVESTIGATORS	ORGANIZATION
Regulation of Natural Gas	Prof. William W. Gibson Mark Lee	School of Law, University of Texas Office of Attorney General
State Constitution	John Odam Vicki Land	Attorney General of Texas Office of Attorney General
Law and Geothermal Resources	Austen Furse Tom Edwards	Oil & Gas Division, Office of the Attorney General Office of the Attorney General
Antitrust Considerations	Joe Longley Ted Siff Bill Marquis Dick Peeples	Antitrust & Consumer Protection Division, Office of the Attorney General of Texas Office of the Attorney General
(Core Program D. - New Technology N/T)		
Potential of Geothermal Steam		Dow Chemical
Texas Lignite	Dr. Tom Edgar	University of Texas Energy Resources Program
Solar Energy Conversion	Dr. J. T. Richardson	University of Houston
Alternatives for Electrical Power	Dr. A. Hildebrandt	University of Houston
Hydrogen and Its Future	Dr. H. H. Woodson	University of Texas/Austin
Supplemental Recovery of Oil	Dr. C. J. Huang	University of Houston
Supplemental Recovery of Gas		Gulf Universities, Research Consortium
Wind Power	Dr. V. Nelson	Gulf Universities, Research Consortium
Tidal and Gulf Stream Power		West Texas State University
Solid Waste Use	Dr. J. Halligan	Texas A&M University Ocean Institute Texas Tech University

Appendix B

Project Publications

Projects of the Supply & Demand Program

- S/D-1 "Energy Supply and Demand in Texas for the Period 1950-1973," Herbert H. Grubb and Milton Holloway, Office of the Governor, Office of Information Services
- S/D-2 "An Economic Analysis of Declining Petroleum Supplies in
S/D-3 Texas: Income, Employment, Tax, and Production Effects as Measured by Input-Output and Supply-Demand Simulation Models," Milton L. Holloway, Herbert W. Grubb, and W. Larry Grossman, Office of Information Services, Office of the Governor
- S/D-4 "Relationship Between Supply/Demand and Pricing for Alternate Fuels in Texas: A Study in Elasticities," Russell G. Thompson, University of Houston
- S/D-7 "Importing Fuels and Petrochemical Raw Materials for Texas," Sadler Bridges, Texas Transportation Institute, Texas A&M University
- S/D-8 "The Impact of and Potential for Energy Conservation Practices in Residential and Commercial Buildings in Texas," Raymond D. Reed, College of Architecture, Texas A&M University
- S/D-9 Volume I, "Fuel Conservation Measures: The Transportation Sector," Ron Holder, Texas Transportation Institute, Texas A&M University
- S/D-9 Volume II, "Fuel Conversion Measures: The Transportation Sector," Ron Holder, Texas Transportation Institute, Texas A&M University
- S/D-10 "Potential for Energy Conservation in Industrial Operations in Texas," H. William Prengle, Jr., University of Houston
- S/D-12 "Energy Consumption, Conservation and Projected Needs for Texas Agriculture," C. G. Coble and W. A. Lepori, Texas Agricultural Experiment Station, Texas A&M University

Projects of the Environmental and Social Program

- E/S-1 "Energy Development and Land Use in Texas," William F. McFarland, Texas Transportation Institute, Texas A&M University
- E/S-2 "Impact on Air Quality of Alternate Strategies for the Production, Distribution and Utilization of Energy in Texas, 1975-2000," Bill Stewart, Texas Air Control Board
- E/S-3 "Impact on Texas Water Quality and Resources of Alternate Strategies for Production, Distribution, and Utilization of Energy in Texas in the Period 1974-2000," G. A. Rohlick, University of Texas, Austin
- E/S-4 "Potential for Designating Selective Emission Standards for Air Pollution Control Based on an Analysis of Climatological Regions in Texas," Alex D. Opiela, Jr., Texas Air Control Board
- E/S-4A "Air Stagnation Advisory Evaluation for Texas," J. F. Griffiths, R. C. Runnels, C. L. Norton, Texas A&M University
- E/S-5 "Sociological Dimensions of the Energy Crisis," David Gottlieb, University of Houston

Projects of the Legal and Regulatory Program

- L/R-1 "Existing Energy Law and Regulatory Practice in Texas," Tom Edwards, John Gangstad, and Ron Snadberg, Office of the Attorney General
- L/R-3 "Energy Conservation," Steve Van, Joyce Carpenter and Marc Wiegand, Office of the Attorney General
- L/R-4 "Legal and Regulatory Policy Aspects of Energy Allocation," Diane Wood, Office of the Attorney General
- L/R-5 "Legal Aspects of State-Owned Oil and Gas Energy Resources," Dan S. Boyd, Office of the Attorney General
- L/R-6 "Tax and Other Legal Incentives to the Increased Production of Energy Resources," Michael T. Johnson, University of Houston
- L/R-7 "State/Federal Regulation of Natural Gas," Mark Lee, Office of the Attorney General

L/R-9 "The Impact of State and Federal Law on Development of Geothermal Resources in Texas," Tom Edwards, Office of the Attorney General

L/R-10 "Antitrust Considerations," Bill Marquis, Dick Peebles, and Ted Siff, Office of the Attorney General

Projects of the New Technology Program

N/T-1 "An Analysis of the Potential Use of Geothermal Energy for Power Generation Along the Texas Gulf Coast," John S. Wilson, Burchard P. Shepherd and Sidney Kaufman, Dow Chemical, USA

N/T-2 "Resources and Utilization of Texas Lignite," T. F. Edgar, University of Texas at Austin, and J. T. Richardson, University of Houston

N/T-3 "Potential of Solar Energy for Texas," A. F. Hildebrandt, University of Houston

N/T-4 "Alternatives for the Texas Electric Power Industry," H. H. Woodson and C. D. Zinn, University of Texas, Austin

N/T-5 "The Implementation of a Hydrogen Energy System in Texas," C. J. Huang and John R. Howell, University of Houston

N/T-6 "Assessment of Enhanced Recovery Technology as a Means for Increasing Total Crude Oil Recovery in Texas," E. Alan Lahse, Gulf Universities Research Consortium

N/T-7 "Assessment of Enhanced Recovery Technology as a Means for Increasing Natural Gas Recovery in Texas," E. Alan Lohse, Gulf Universities Research Consortium

N/T-8 "Potential for Wind Generated Power in Texas," Vaughn Nelson, West Texas State University and Earl Gilmore, Amarillo College

N/T-9 "Potential of Tidal and Gulf Stream Power Sources," John Savage, Southern Methodist University

N/T-10 "Potential for Solid Waste as an Energy Source in Texas," James E. Halligan and William J. Huffman, Texas Tech University

Coordinated Projects

II/A "Texas Nuclear Power Policy: An Analysis of Alternatives," H. H. Woodson and J. H. Vanston, University of Texas, Austin

Special Projects

Special Project A, "1974 Texas Farm Fuel and Fertilizer Survey," Charles
Charles E. Claudill, Agricultural Statistician in Charge Texas
Crop and Livestock Reporting Service

Special Project B, "Survey of Texas Petroleum Refineries,"
Texas Mid-Continent Oil and Gas Association

Special Project C, "Petrochemicals in Texas - 1972,"
Petrochemical Energy Group

Special Project E, "U.S. Energy Development: Four Scenarios,"
Frank Maslan, The Futures Group, Glastonbury, Connecticut

Special Project F, "Texas Energy Scenarios," R. D. Finch, University
of Houston, and Harriet Hahn, Division of Planning Coordination,
Office of the Governor



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 39

TERTIARY OIL RECOVERY

UNIVERSITY OF TEXAS

39-1

Case Investigator:

M. v.E. Rulison

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

Dinesh O. Shah

Department of Chemical Engineering
University of Florida
Gainesville, Florida 32611

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

TERTIARY OIL RECOVERY

Introduction and Summary

Enlarging domestic supplies of energy is a national need that has assumed increasing importance in the 1970's. The great majority of oil in any given oil field remains captive after current economically feasible primary and secondary recovery processes have been used. This project, initiated at the University of Texas in 1974, is concerned with the phenomena of interfacial tension between oil and brine and the potential for tertiary recovery of captive oil by reducing the interfacial tension through the addition of chemicals to the oil-brine mixture. This project is being led by Co-principal Investigators Dr. William H. Wade and Dr. Robert S. Schechter, Chairmen of the Departments of Chemistry and Petroleum Engineering, respectively.

In their work, which is now entering its third year, the investigators are focusing on identifying the properties of chemicals (surfactants), and of crude oils and the rock environments in which they are found, that jointly influence the interfacial tensions between brine and crude oil. These interfacial tensions must be reduced to very low levels if captive crude oil (remaining after present recovery process has been used) is to flow through the rock reservoir structure so that it can be recovered. They are also investigating the characteristics of this chemical-oil-brine-rock system that affect the adsorption and absorption of the chemicals by oils and rocks, processes that make the chemicals unavailable for the purpose of enabling the oil to flow.

The relevance of this research lies in the systematic attempt being made by Drs. Wade and Schechter, using greatly simplified systems of chemicals, oil, water, and rock compared to those found in the field, to identify the characteristics of each component that are critical to the behavior of the system. Such research is needed at this time because, although oil company laboratories have identified systems that promise to improve oil recovery, they have typically worked with very complex systems of chemicals and oil. Thus, it is difficult to determine what changes in the system would enhance oil recovery. The goal of the project at the University of Texas, working with simplified systems, is to define and specify the important relations among the characteristics of the system components.

NSF/RANN funding of the project and other data are given in table 39-1. It should be noted that eleven oil companies are now contributing \$55,000 a year to the project.

The most tangible product of the research to date is an apparatus for measuring very low interfacial tensions. This apparatus--a spinning drop interfacial tensiometer--was developed by the investigators and has been produced by the Chemistry Department of the University of Texas.

Other tangible products of the research are more than a dozen papers prepared, or in preparation, for publication and presentation at meetings. Numerous seminars have been given for both academic institutions and industrial organizations. Graduate students are just beginning to complete their studies and move to jobs where their background can be applied to problems of enhanced oil recovery.

A less tangible product is the increased communication among top industrial research persons through their participation on the Advisory Panel that monitors the progress and direction of this project. The semiannual meetings

Table 39-1. PROJECT INFORMATION

Project Title Tertiary Oil Recovery Processes	Grant/Contract No. GI-42497
RANN Program Manager Dr. Donald Senich, Director, Division of Advanced Energy and Resources Research and Technology	RANN Program Area Fossil/Energy Resources
Principal Investigator(s) William H. Wade, Department of Chemistry Robert S. Schechter, Department of Petroleum Engineering, Department of Chemical Engineering	Schedule Start: 1 April 1974 End: 31 October 1977
Institution University of Texas at Austin Austin, Texas	Funding NSF: \$349,900 Other: \$140,000 from industry to date
Contributors/Collaborators None.	
User Advisory Committee 10 persons from the petroleum industry, 2 persons from Government (Bureau of Mines, National Science Foundation) and the Co-principal Investigators (see list in Appendix A).	
Precursor Activities Prior experience and communication with elements of the petroleum industry research personnel.	

of this panel are considered quite fruitful by those attending from industry, in addition to providing useful direction to the project team.

To date, about 50 spinning drop tensiometers have been supplied to various laboratories. This constitutes a clear form of utilization.

The use of project findings is less readily assessed. Published material is available to workers in this field. Because the tasks scheduled for this project are only partially completed and because, by design, it deals with systems that are much simpler than those with which oil companies must deal in actual operations, the full effects of this research will not be apparent until it is complete and the industrial laboratories have had an opportunity to analyze and apply principles and relations developed in the project to specific situations.

The dissemination and utilization of project results to date have certainly been positively affected both by the long-term professional association of the Principal Investigators with researchers in the petroleum industry, and by the active role Drs. Wade and Schechter have taken in publishing and making presentations.

Given the fact that the project is still in progress, with significant tasks yet to be carried out, and that it deals with rather basic relationships that industry must apply to its own situation, it can be concluded that dissemination has been active and successful and that utilization is quite consistent with project progress.

Research Description

Reservoirs of petroleum typically exist in porous rock beds from which only about 30 percent of the oil is recoverable using primary (natural pressure)

and secondary (water forcing) techniques. Thus, almost 70 percent of the oil in a given reservoir is not commercially available because of economic and technical considerations. The difficulty in removal stems from the viscosity and/or interfacial tension of many crude oils and from the variation in the pore size of the rocks in which they are found. Together these characteristics impede flow of the oil through narrow necks of pores in the rocks of the reservoir; the oil is, in effect, captured in the rocks by capillary and/or viscous forces.

The purpose of this research project is to uncover certain relations existing in the oil-brine-rock system when selected chemicals are added. Knowing those relations, it may be possible to design an economically feasible tertiary recovery system for extracting this "residual oil." This technology is known as chemical flooding or enhanced oil recovery (EOR).

The possible benefits of EOR in the United States are great, since oil now left in fields when primary and secondary recovery ends is about twice as much as has been extracted. A technology for tapping this captive oil would help meet an important national need.

Enhanced oil recovery requires actions that will enable oil droplets to move through rock pores into well bores from which the oil can be pumped to the surface. One way that this can be accomplished is by lowering the interfacial tension between globules of oil and the salt water and rock in which they are found. Another promising method is the inducement of spontaneous chemical emulsification in which the exterior of each globule is shed into the surrounding water until the globule itself is small enough to move through the rock pores effectively. This NSF/RANN project focuses upon the creation of systems with low interfacial tensions (approximately 0.001 dyne/cm or lower), compared to interfacial tension of 10-30 dynes/cm in natural oil-water systems.

The chemical agents that create ultra-low interfacial tensions are known as surfactants. In petroleum recovery, three types of surfactants have been investigated: "mahogany" sulfonates, refinery distillate or gas oil sulfonates, which are produced by direct sulfonation of refinery streams, and synthetic sulfonates.

The role of low interfacial tension between oil and brine phases in relation to oil recovery was demonstrated almost 50 years ago.* Until the mid-1960's, according to the Principal Investigators, oil company scientists were studying the basic physical chemistry phenomena that were important to the recovery of residual oil. About a decade ago, petroleum company laboratories shifted their research focus to emphasize applied studies. Fundamental research projects were phased out. Even so, several companies had obtained some useful results in enhanced oil recovery and one, Marathon Oil Company, has offered its "Maraflood" recovery process on the market. Throughout this period, one of the Principal Investigators, Dr. William H. Wade, maintained contacts with several oil company scientists studying physical chemistry phenomena. In the early 1970's when the companies had largely shifted away from fundamental research, Dr. Wade, who had been increasingly interested in certain applied problems, moved toward more detailed examination of the application of surface chemistry to oil industry problems. At that time, Dr. Robert S. Schechter, now Chairman of the Department of Petroleum Engineering at the University of Texas at Austin, became involved in the effort and a grant proposal was prepared. This project was proposed to NSF/RANN in August 1973 and funded in April 1974. Meanwhile, work had started on a part of the research

* L.C. Uren and E.H. Fahmy, Petroleum Development and Technology, Petroleum Division, AIME (1927).

dealing with spontaneous emulsification with funding provided by the U.S. Bureau of Mines in November 1973.

The essence of this project is a search for the means and conditions under which ultra-low interfacial tensions between oil and water can be produced and maintained for the period of years (perhaps up to three) during which tertiary oil recovery could take place.

The first objective of the project was to develop a satisfactory method of measuring interfacial tensions. Although some oil companies had techniques satisfactory for specific requirements--i.e., the sessile drop and pendent drop device--the reproducibility and ease of use of these techniques were questionable in Dr. Wade's opinion. Using ideas presented in the literature, the project team devised the spinning drop interfacial tensiometer and developed it to the point where the University could make it. This instrument will measure interfacial forces on the order of one hundred-thousandth of a dyne per centimeter (10^{-5} dyne/cm).

Having developed the capability for making needed measurements, Drs. Wade and Schechter then embarked on a systematic description of the characteristics of oil-brine-surfactant systems. Industrial laboratories had worked on this endeavor, but usually with crude oils and commercial surfactants. Both these materials consist of mixtures of chemical compounds differing in molecular weights and numerous other characteristics. In order to derive essential basic data, Drs. Wade and Schechter carried out experiments in which complex, commercial surfactants were used in systems where the oil was a single hydrocarbon compound. They then moved to mixtures of surfactant and two hydrocarbons. As a result of their ability to measure ultra-low interfacial tensions and this systematic approach, within the first year of the project they were able to formulate significant guidelines for tailoring surfactants to be

effective with particular crude oils in laboratory situations.

Tasks currently underway or planned include:

- An attempt to understand the properties of surfactant molecules that make them effective in creating low interfacial tensions, and
- An examination of the factors affecting adsorption of surfactant onto rocks and absorption of surfactant into oil because both of these processes decrease the amount of surfactant available to enhance oil recovery and increase process cost.

This work involves careful experimentation to identify and describe the single and joint effects on oil recovery of such factors as the temperature and salinity of the reservoir, molecular weight and chemical structure of the surfactant and the crude oil, the type of rock in which the reservoir is located, and the usefulness of additional compounds, such as certain alcohols. Work to date has shown that the chemical system involved is not only complex, in the sense that many factors are involved, but is also sensitive to small changes in process parameters. For example, a small difference in the molecular weight of the oil makes a large difference in the response to a given surfactant.

Another of their findings has been identification of an aging process in surfactant solutions. This process diminishes the effective life of the surfactant during a period of months and may prove to be a barrier to tertiary recovery of oil, since the recovery process typically requires a period of years for completion. The investigators have also identified some surfactant solutions that do not age. Now that this potential and previously unsuspected problem has been identified, effort can be directed by the research community toward its resolution.

Thus, much of the work of this project is devoted to studying simplified

systems with carefully ordered variation to sieve out the effects of the several different factors in isolation and jointly. Because very large amounts of chemicals will be needed to achieve tertiary recovery, it is important to find the sets of conditions that produce results with the minimum amounts of chemicals.

As Dr. Wade sees the project's results at this time, development of the spinning drop tensiometer is of secondary importance, while their finding of guidelines for developing ultra-low interfacial tensions in mixtures of brine, surfactant, and hydrocarbons is primary. Also of major importance are other findings such as the aging of surfactant solutions and the differences in behavior between "dead" oils taken from stock tanks and "live" crude oils containing significant quantities of dissolved methane. Overall, Dr. Wade believes the major effects of his project with Dr. Schechter will become most apparent within three or four years.

Utilization Objectives

The primary users of this research are companies engaged in oil production who face the need for keeping oil fields producing at rates that justify their lease costs.

Secondary users are researchers in academic institutions and other public and private laboratories where the action of surfactants is of interest. Such users are not restricted to the oil industry, but may include, for example, such areas as food chemistry, detergents, and biomedicine.

The most immediate and tangible application of this project to date has been the purchase and use of about 50 spinning drop tensiometers by research organizations. The less tangible application is the use by industry of research

results announced thus far, in determining the course of their research to make enhanced oil recovery practical in their own specific production situations. According to Drs. Wade and Schechter, at least one major oil company is believed to be re-evaluating its program for enhanced oil recovery. Another form of utilization is the employment of persons who have worked in this project as graduate assistants by firms in the industry. One former student has been hired by one of the suppliers of surfactants to the petroleum industry.

The utilization plan for this project evolved very logically out of the stimulus from industry to induce this sort of research by the Principal Investigators. Given marked industry interest in the research, and a need by the investigators to become well-grounded in the precise problems, industry involvement in the form of an Advisory Panel was natural. (See Appendix A for composition of Advisory Panel.) The exchanges among members of the panel are cited by both the investigators and the users as being highly rewarding. Two meetings of the panel are scheduled each year. One of the meetings is planned to coincide with a conference open to all interested parties.

In addition, the Principal Investigators and their associates have made presentations at various meetings, both in industry and at academic institutions. (See list in Appendix B.) Appendix C is a selected list of project papers published by project staff.

Utilization Obtained

Petroleum Companies and Other Industries

Dr. J. J. Rathmell is Project Leader of the Core Properties and Chemical Flooding Project at the Atlantic Richfield Research and Development Department in Dallas (Plano), Texas. He represents his company on the Advisory Panel for

this project. Atlantic Richfield has purchased and placed in use two spinning drop interfacial tensiometers developed at the University of Texas. He believes this instrument may have had a value to Atlantic Richfield of about one man-year of effort in terms of their ability to move ahead with studies of ultra-low interfacial tensions. He notes, however, that this opinion would not necessarily be shared by companies that had already established suitable measurement methods. Other project outputs already in use at his company, according to Dr. Rathmell, are the scaling rules that show how to relate surfactant properties to crude oil properties and the relations of interfacial tension to each of several variables. He adds that his company has been independently doing some work in this area.

He asserts that the current work at the University of Texas project with commercial surfactants and several series of pure hydrocarbons--rather than with crude oils, which are extremely complex mixtures of hydrocarbons--is "extremely important" to industry.

Dr. Rathmell indicated that Atlantic Richfield would have been much less inclined to support this work financially without the Advisory Panel feature, which he perceives as having large, though intangible, benefits by opening scientific communication among the oil companies and providing a forum through which researchers can check their results.

In Dr. Rathmell's opinion, the project work to be undertaken by Dr. Schechter in connection with the adsorption of pure surfactants should be pursued vigorously since this may be the most important factor in determining the cost of enhanced oil recovery through its effect on the amount of surfactant needed. He would also like to receive research results with more interpretation and discussion of the overall significance of the work rather than in the several individual papers and the data presented. Overall, however, he

believes that the program is run very well and that the collaboration of Drs. Wade and Schechter is synergistic, with results greater than they would achieve singly.

Dr. Karl D. Dreher is a senior research chemist in the Petroleum Chemistry Department of the Denver Research Center of Marathon Oil Company. He learned of the project when the paper on the spinning drop apparatus "caught his eye." Marathon has bought three of these devices and follows the published results with interest, although their own company approach is more pragmatic--in response to the economics of producing surfactants. He says the project is very timely and that they have no difficulty in obtaining access to project publications.

Dr. Earl Malmberg is Chief Scientist for Chemistry at Suntech Company, Dallas (Richardson), Texas, a subsidiary of the Sun Company, which was formerly the Sun Oil Company. He is a member of the project Advisory Panel.

Dr. Malmberg says the Sun Company is not especially concerned with using interfacial tension measurements, but nevertheless he finds the concepts developed by Drs. Wade and Schechter important and is struck by the relationships being established, which appear to depart from some of the usual concepts of colloid chemistry. His company has bought one of the spinning drop tensiometers, but uses it only secondarily for measurements related to surfactants.

Dr. Malmberg describes the meetings of the Advisory Panel, and their informal sessions in the evening, as "very helpful," stating that they develop an atmosphere of freedom and exchange that is not characteristically present at the professional meetings of petroleum industry workers, where communication may be isolated and restricted. He sees the panel as functioning effectively to guide the project, which he hopes will move from the study of interfacial tensions into other areas, including the role of alcohols as agents

complementing the action of surfactants and the actual recovery of oil from sample cores with various systems of oil, salt water, and surfactants to test the hypotheses that have been developed thus far.

Dr. James C. Melrose is a senior research associate at the Mobil Research and Development Corporation in Dallas, and a member of the project Advisory Panel. He characterizes his company as having developed its own capability for measuring interfacial tensions and not a strong user of the project results to date, partly because Mobil began its work in this field earlier than most companies and is already embarked upon field testing of tertiary recovery systems. He notes that several papers issued thus far do contain new information about the physical chemistry of the oil recovery system. Dr. Melrose is completely satisfied with the dissemination of results in this project, stating that he likes the semiannual Advisory Panel reviews in which data are presented "hot off the stove." He believes all the oil companies are very pleased that academic scientists have entered this field in which "backup, basic research" is needed more strongly than ever since the oil companies phased out of basic investigations. He views this project as providing much needed theoretical, orderly structure from which better oil recovery systems can be devised. Oil company work has tended to focus on an empirical approach serving the needs of operating companies as directly as possible, but often without the resources to obtain a broad understanding of the process. Noting that the National Science Foundation has now sponsored two other projects relating to tertiary oil recovery (at the University of Florida and the University of Minnesota), Dr. Melrose said he is looking forward to a review meeting being planned by Dr. Senich, the NSF/RANN Program Manager, at which investigators from all three projects will present findings and discuss them with industry representatives.

Dr. R.L. Reed is Research Supervisor, Reservoir Division, Exxon Production Research Company, Houston, Texas, and a member of the project Advisory Panel. His organization is using project results directly, through its purchase of one spinning drop tensiometer. He believes that other project results are helping them conceptually, but says the research has not progressed far enough to help them on a practical basis. He is hoping that further project effort will identify a pure hydrocarbon that can be substituted for crude oil in studies of the effects of surfactants in sample rock cores, not merely in test tubes. Dr. Reed states that the University of Texas investigators are very good about keeping industry informed on their activities through the papers they issue, through their participation in professional meetings, and by giving seminars at academic and industrial institutions. Like several other members of the Advisory Panel, Dr. Reed has known Drs. Wade and Schechter for many years, thus he was aware of this research as it was being formulated and his company was one of the first to give its financial support of the project. In addition, Dr. Schechter has provided consulting services to Exxon in the past, thus creating another channel of communication.

Dr. George J. Hirasaki is Staff Supervisor of the Chemical Flooding Section, Petroleum Engineering Research Department, Bellaire Research Center, Shell Development Company, Houston, Texas, and serves on the project Advisory Panel. He states that utilization of project results at Shell includes acquisition of two or three of the tensiometers and circulation of copies of project papers to their staff. Dr. Hirasaki says they are not making direct use of the project findings in designing their recovery process, but that the results are affecting their understanding of the process.

The project is very timely; it is not ahead of its time and could have been used earlier according to Dr. Hirasaki. He notes that the present

interest intensified at the time of the Arab oil embargo although initial industry work in enhanced oil recovery began in the 1960's. In some areas, he believes industrial laboratories are ahead of the University of Texas group, but the industrial work is not performed with a comparable degree of detail.

Dr. Hirasaki points to experience in the project or related research as improving the educational background of students, making them more useful to industry because of their understanding of the types of problems faced by the oil companies. He indicates the Advisory Panel is actively providing guidance and suggestions to the investigators.

Dr. Robert L. Wells is a staff scientist at the Miami Valley Laboratory of Proctor and Gamble Company, Cincinnati, Ohio. He attended the Symposium, "Research on Enhanced Oil Recovery," presented by the University of Texas project staff in August 1975, having learned about the project through the professional literature and his contacts in the Colloid Section of the American Chemical Society. He wanted to learn about the techniques for measuring ultra-low interfacial tensions. Subsequently, Proctor and Gamble purchased one of the spinning drop tensiometers. Dr. Wells says the technical results of the project thus far are interesting, but that his firm has not made specific use of them, though they do have research interests both in tertiary oil recovery and in other areas. He asserts that the investigators are doing a good job in disseminating project results through their talks and papers.

University and Research Users

Dr. D.T. Wasan is Chairman of the Department of Chemical Engineering at the Illinois Institute of Technology in Chicago. He has known Dr. Schechter through professional contacts for a number of years. Dr. Wasan's work in enhanced oil recovery goes back several years and involved very basic studies.

As a result of the design information published by Wade and Schechter, Dr. Wasan's group has built its own spinning drop apparatus. At present, Dr. Wasan has a proposal under consideration by NSF for research in enhanced oil recovery. He believes the proposed study would extend and complement the work in the University of Texas project. Upon funding, he would expect to communicate intensively with the Texas investigators about their activity, because in his work, he wishes to study some of the same surfactant systems, measuring certain properties relating to the coalescence of oil droplets (ganglia) and the stability of emulsions that affect recovery. Dr. Wasan believes it would be helpful if progress reports made to NSF/RANN about this project were made available to a wider audience of researchers, beyond the Advisory Panel.

Federal Agencies

Dr. P.B. Lorenz is a research chemist in the Tertiary Recovery Subgroup of the Production Group at the Bartlesville (Oklahoma) Energy Research Center of the Energy Research and Development Administration (ERDA). The Center was formerly operated as part of the U.S. Bureau of Mines.

He learned about this project through a request from NSF/RANN to review the original proposal. Because of their enthusiasm for the work program, his agency provided a separate grant of \$25,000 to the University to undertake a part of the proposed work dealing with spontaneous emulsification. This grant was for one year beginning in November 1973. It was subsequently increased to a total of \$80,000 covering three years for work that complements, but is separate from the NSF project.

Dr. Lorenz says the Center has purchased one of the spinning drop tensiometers and is making use of project results dealing with the distribution of surfactants between oil and water phases in their own work on the influence of

wettability on oil recovery. The Center has sought to employ persons who have done their graduate work in connection with this project, but has not yet secured such a person. On the whole, Dr. Lorenz gives this project high marks for execution and dissemination, although he notes that in some cases, papers might be improved if more time were allowed for collection and analysis of data.

Features

The Principal Investigators in this study appear to have influenced the awareness and utilization of the results from this project through their considerable discussions with industry scientists before this project was conceived and launched, as well as by their approach to the work, including for example, informal social sessions the night prior to each Advisory Panel meeting. They assert their earnest attempts to cooperate and deal fairly with the oil industry in this work and, accordingly, have eschewed consulting assignments for the industry since embarking on the project. To avoid the problems of breaching industrial security they have, to some extent, tried to insulate themselves against knowing exactly what certain firms were doing. Even though this may have involved some costs in terms of time, they believe it to have been worthwhile in terms of maintaining rapport with the industry. Dr. Wade, in particular, has made special efforts to reconcile differences in results obtained by the project and those found by industry researchers and, on some occasions, provides industry with needed physical measurements.

NSF/RANN management, handled by Dr. Donald Senich, Director, Division of Advanced Energy and Resources Research and Technology, has influenced the project from its beginning, first by limiting the initial request to 24 months

of time and funds (later expanded to 43 months and \$349,900 total), by insuring that the Principal Investigators maintained their schedule of industrial contacts; and finally, by funding two other projects related to enhanced oil recovery. The latter provide additional approaches and make the NSF/RANN program more complete, and may also create some sense of competition among the investigators and their institutions, thus enhancing overall progress.

User commitment to the importance of this work must be rated very high in view of industry willingness to participate in funding the project. At the present time, \$5,000 a year is being contributed by each of 11 companies, up from the three companies who indicated their support at the time the original proposal was submitted. Dr. Wade reports that the project has received \$140,000 in funding from industry to date.

In terms of timing, this project appears to be underway at about the right time. Several persons voiced the opinion that funding would not have been forthcoming earlier when the problem of oil supply was less critical. Given the need for industrial research to apply the results of this project to the specific conditions encountered by each company in its own oil fields, and the major costs of closing an oil field before tertiary recovery is achieved, the five-year work program originally foreseen by the investigators is needed promptly.

Conclusions

This NSF/RANN project involves basic research directed toward the understanding of the physical and colloid chemistry phenomena involved in tertiary recovery of petroleum from oil fields. Insofar as the techniques and principles developed in this project can be used by industry in designing systems to

enhance oil recovery, they are satisfying a specific and important national need. This carefully planned project has been underway about two years and is now funded for another year and a half; thus, the Principal Investigators still have a number of tasks to undertake. Nevertheless, at this time (June 1976), they can report significant results. One salient result is the design and construction of a device for measuring ultra-low interfacial tensions. This device improves the capability for gathering satisfactory data and thus facilitates research. But more important, the results of work to date in this project have begun to clarify the relations between the characteristics of chemical additives and the crude oils that are to be recovered. As these relations are described systematically, it becomes possible to design enhanced recovery systems that may be economically feasible. The results of this project are intended to support such efforts by the petroleum industry.

A particularly significant finding has been the discovery that some surfactant solutions age and diminish in effectiveness over relatively short periods of time. The prompt reporting of this finding to the petroleum industry by the project team enabled designers of enhanced oil recovery processes to take this phenomenon into account and to develop means to avoid or inhibit the aging process.

Clear evidence of utilization is seen in the project funding received from industry, which currently amounts to \$55,000 a year.

In the case of this project, a federally-funded program enhances the potential utilization over that which could be attained had the research been accomplished by private industry with its associated proprietary restrictions. Research results have been available to the entire oil industry, not merely to members of the Industry Advisory Panel. The research results have been actively disseminated through numerous technical papers published or delivered at meetings.

Appendix A

Advisory Panel for Tertiary Oil Recovery

<u>Name</u>	<u>Company</u>	<u>Address</u>
Dr. Jae Ho Bae	Gulf Research and Development Company	Pittsburgh, Pennsylvania
Dr. E. Clippinger	Chevron Oil Field Research LaHabra Laboratory	LaHabra, California
Dr. H. Gilliland	Continental Oil Company	Ponca City, Oklahoma
Dr. G. J. Hirasaki	Shell Development Company Bellaire Research Center	Houston, Texas
Dr. Elton Hunt	AMOCO Production Company	Tulsa, Oklahoma
Dr. P. B. Lorenz	Energy Research and Development Administration Energy Research Center	Bartlesville, Oklahoma
Dr. Earl Malmberg	Suntech Company	Richardson, Texas
Dr. Frank Marcotte	Witco Chemical Corporation	Petrolia, Pennsylvania
Dr. J. C. Melrose	Mobil Research & Develop- ment Corporation	Dallas, Texas
Dr. J. J. Rathmell	Atlantic Richfield Research & Development Department	Dallas, Texas
Dr. R. L. Reed	Exxon Production Research Company	Houston, Texas
Dr. Robert S. Schechter	The University of Texas Department of Petroleum	Austin, Texas
Dr. Donald Senich	National Science Foundation Energy Program of RANN	Washington, D.C.
Mr. Eugene Knaggs	Stepan Chemical Company	Northfield, Illinois
Dr. William H. Wade	The University of Texas Department of Chemistry	Austin, Texas

Appendix B

Selected List of Meetings at Which Presentations Have Been Made

Gordon Research Conference on Subsurface Flow	August 1975
Energy Research and Development Administration Conference	September 1975
Society of Petroleum Engineers, National Meeting	October 1975
Society of Petroleum Engineers, Regional Meeting	March 1976
American Chemical Society, Short Course (two presentations)	March 1976
American Chemical Society Meeting, Kindal Award Symposium	April 1976
Society of Petroleum Engineers, Enhanced Oil Recovery Meeting	April 1976
American Institute of Chemical Engineers, National Meeting	April 1976

Appendix C

Selected Bibliography of Papers

by Project Staff

R. L. Cash, J. L. Cayias, M. Hayes, D. J. MacAllister, T. Schares and W. H. Wade, "Surfactant aging: A possible detriment to tertiary oil recovery," paper SPE 5564, presented at 50th Annual Fall Meeting of SPE-AIME, Dallas, Texas, 1975.

R. L. Cash, J. L. Cayias, G. Fournier, K. J. Jacobson, C. A. LeGear, T. Schares, R. S. Schechter and W. H. Wade, "Low interfacial tension variables," in Proceedings of the American Oil Chemists' Society Short Course, Hershey, Pa., June 1975.

R. L. Cash, J. L. Cayias, G. Fournier, J. K. Jacobson, T. Schares, R. S. Schechter and W. H. Wade, "Modeling crude oils for low interfacial tension," paper SPE 5813, presented at SPE Symposium on Improved Oil Recovery, March 1976.

R. L. Cash, G. Fournier, K. J. Jacobson, J. C. Morgan, T. Schares, R. S. Schechter and W. H. Wade, "Low interfacial surface tensions involving mixtures of surfactants," to be presented at SPE-AIME 51st Annual Meeting, New Orleans, October 1976.

R. L. Cash, J. L. Cayias, G. Fournier, D. J. MacAllister, T. Schares, R. S. Schechter and W. H. Wade, "The application of low interfacial tension scaling rules to binary hydrocarbon mixtures," J. Colloid and Interfacial Science, (in press).

J. L. Cayias, R. S. Schechter and W. H. Wade, "The Measurement of low interfacial tension via the spinning drop technique," in Adsorption at Interfaces, ACS Symposium Series No. 8, 1975.

J. L. Cayias, R. S. Schechter, and W. H. Wade, "The utilization of petroleum sulfonates for producing low interfacial tensions between hydrocarbons and water," J. Colloid and Interfacial Science, (in press).

J. L. Cayias, M. E. Hayes, G. D. Jones, R. S. Schechter and W. H. Wade, "Spontaneous emulsification--a possible mechanism for enhanced oil recovery," J. Petroleum Technology, (in press).

P. H. Doe and W. H. Wade, "Alkyl benzene sulfonates for producing low interfacial tensions between hydrocarbons and water," presented at 171st Meeting of American Chemical Society, New York, April 1976.

J. C. Morgan, R. S. Schechter and W. H. Wade, "Recent advances in the study of low interfacial tensions," presented at Meeting of American Institute of Chemical Engineers, Kansas City, April 1976, (to be published as book chapter).



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 40

ASSESSMENT OF A NEW TEXTILE TECHNOLOGY

NORTH CAROLINA STATE UNIVERSITY

40-1

Case Investigator:

R. Whisnant

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

D. Turner

Dental Research Center
University of North Carolina
Chapel Hill, North Carolina 27514

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

ASSESSMENT OF A NEW TEXTILE TECHNOLOGY

Introduction and Summary

This research, under the direction of Dr. W. K. Walsh of North Carolina State University (NCSU), is designed to perform applied research and provide information on applications of radiation for curing of resins in the textile industry. The objective is to assist companies having an interest in this technology to make rational management decisions concerning it. Three industries have potential interest in the technology: the textile industry, the chemical industry, and the radiation process equipment industry. Of these, the textile industry has the greatest need for assistance.

The textile industry, employing approximately one million people and contributing about \$30 billion to the economy, is highly fragmented and, as a result, has a very low level of research and development. This low R&D level is exacerbated by the fashion market orientation of the industry, requiring continual product adaptation. As a result, developments in processes and chemical products for textile finishes are usually made by the textile machinery manufacturers and the suppliers of chemicals used in the industry.

The radiation polymerization technology addressed by the program reported in this case study has been used in other industries, e.g., printing, metal coating, wood coating, and plastic film manufacturing; and has resulted in reduced energy requirements, increased productivity, and reduced air and water pollution. In addition to these possible benefits, adoption of the process by the textile industry could result in reduced flammability of textile products; thus, application of radiation polymerization

technology in the textile industry has the potential for contributing to the satisfaction of several national needs.

Data generated by this program have been disseminated to the textile industry, suppliers of textile chemicals, and radiation equipment manufacturers, primarily through the program Advisory Committee. Short courses at NCSU have also served as an effective dissemination mechanism and have created a continued interest in applications. Several firms are currently investigating applications on a laboratory scale or are re-evaluating their interest in the technology.

Utilization experience to date indicates that the textile industry is reluctant to adopt the technology because they do not perceive either advantages in products or in the energy and environmental areas as offsetting the capital and operating costs. However, a high level of interest has been maintained by the various companies so that they are prepared to adopt the technology when and if its advantages and industry conditions combine to make it commercially attractive.

The research program has served as an excellent coordinating factor in advancing the technology and knowledge of radiation polymerization applications to textiles that will enhance utilization as economically attractive processes and products are identified. In addition, the effort is viewed as fulfilling an industry need for supportive research that is not otherwise available.

Research Description

During his 16 years at North Carolina State University, the research of Dr. Walsh has focused on radiation curing of resins. In 1974, he submitted

Table 40-1
PROJECT INFORMATION

Project Title High Energy Radiation for Textiles: Assessment of a New Technology	Grant/Contract No. GI 43105
RANN Program Manager Dr. J.C. Aller	RANN Program Area Advanced Productivity Research and Technology
Principal Investigator(s) Dr. William K. Walsh	Schedule Start: April 1974 End: April 1977
Institution School of Textiles North Carolina State University Raleigh, N.C.	Funding NSF: \$300,000 Other: \$5,000 (Thiokol)
Contributors/Collaborators: Dr. D.M. Cates, Dr. B.S. Gupta, Dr. M.H. Mohamed, Dr. W.D. Cooper, Dr. M.R. Shaw	
User Advisory Committee: Approximately 20 members from industry	
Precursor Activities: Prior research by the contributors and principal investigator	

a proposal to NSF/RANN for a three-year program to apply the results of his basic research to problems within the textile industry. This proposal resulted in a grant for which information is given in table 40-1. The only other NSF funding to Dr. Walsh was a grant for equipment of about \$27,000 prior to this contract from the Engineering Division of NSF.

The objective of the research is to assess the potential of radiation curing of resins in textile products as an alternative to the conventional thermal curing. The six areas that were proposed for the study, four involving adhesives and two involving fire retardants, are described in the following paragraphs.

Nonwoven fabric bonding - Nonwoven fabrics bypass some expensive process steps in producing fabrics by depending on adhesives to provide the basic fabric integrity. Poor adhesive bonding has prevented the manufacture of nonwovens with both good strength and the softness inherent in woven and knitted fabrics. One phase of this research has investigated the use of radiation polymerization to overcoming this inherent problem in nonwoven fabrics.

Flocked fabrics - Flock fibers are applied to a backing fabric with an adhesive that determines the durability of the flock fabric facing. The use of radiation curable adhesives has been investigated to improve flocked fabric properties and to reduce the energy used in their manufacture.

Bonding of pigment prints - In pigment printing, the pigments are dispersed in a solution containing a resin bonding agent, and the resulting mixture is printed onto the fabric, dried, and cured. This process is limited in the depth of shade obtainable due to adhesion problems with the resin. The use of radiation curable adhesives to improve adhesion and overcome the depth of shade problems has been investigated.

Crimp stabilization in bulk yarn - Continuous filament synthetic yarns are often treated to give them additional bulk so as to provide a greater covering power and more luxurious feel in such end products as carpets, sweaters, hosiery, and related garments. The objective of this portion of the research was to determine if a radiation cured finish on carpet yarns would increase pile height, covering power and compressional resistance.

Flammability of synthetic fibers - The interest in radiation curing for improved flammability resistance stems from the need for improved adhesion to the fibers of compounds which promote that resistance. While flame

resistance of a newly treated fabric may be substantial, repeated washing tends to remove the compounds and increase flammability. This applies to cellulosic as well as synthetic fibers. The investigation of synthetic fiber flammability was discontinued after preliminary investigations principally because of overlap with a National Bureau of Standards/Experimental Technology Incentives Program (NBS/ETIP) on the same subject being conducted by RTI and Clemson University. Dr. Walsh has collaborated on that program.

Flammability of cellulosics - This research area is still being actively pursued. Major distinctions in approaches to cellulosic flammability versus synthetics are due to the differences in absorption properties of the fibers (cellulosics absorb readily), and the flammability of the fibers themselves (synthetics only melt and char).

The polymerization of resins may be carried out by either electron or ultraviolet light irradiation. The electron beam method utilizes a high voltage (~300Kv) source of electrons operating in a vacuum. The electron beam produced is focused into rectangular shaped beams by electromagnetic means and passes through a thin, metallic window directly onto the fabric. The resins are applied to the fabric prior to exposure, which may or may not take place in an inert atmosphere. The basic advantage of electron beam irradiation is the higher penetration of the beam as compared to ultraviolet light. For curing thick films or penetration, into fabric interstices, the higher energy electron beam is essential.

The ultraviolet radiation method utilizes conventional sources of ultraviolet light, and provides a rapid cure of thin-layer polymers. It has been effective in such applications as printed beverage can labels, magazine printing, and coatings for wood and metal.

The equipment used in laboratory experiments at NCSU simulates the exposure of production equipment on stationary fabric instead of full-width moving webs. The only significant drawback to this arrangement is that quantities of treated fabric sufficient to test market applications cannot be produced. A pilot-scale facility, including resin application and fabric transport equipment, is needed to develop applications.

The utilization of ultraviolet (UV) and electron beam sources in polymerization is becoming widespread outside the textile industry. Ultraviolet curing of printing inks in magazines and on beverage containers and curing of coatings on metal panels in the automobile industry and on particle board and other wood products for the furniture industry has been commercialized. Other applications include the vulcanization of rubber, cross-linking of plastic films, and coating of wire and cable.

Utilization of radiative polymerization in the textile industry is mixed. The Deering Milliken Corporation in the mid-1960's developed and commercially applied to textile fabrics electron beam irradiation to a particular approach to bonding of finish resins called graft polymerization. This process is still in use, although at a currently low level due to changing product requirements. Deering Milliken is interested in other applications for the process. Following successful applications of UV curing in other industries in the early 1970's, there was some renewed interest in the textile industry in the application of ultraviolet curing. However, it was found that the limited penetration of UV into the material did not permit its use for most textile products. An electron beam apparatus with greater penetration is currently being installed by United Merchants in their research center in Langley, S.C. Aside from that installation, there

is no other known application in firms that produce fabric or other fiber substrates.

A 20-member Advisory Committee was formed including representatives of major textile manufacturers, radiation processing equipment manufacturers, and chemical suppliers. This committee initially reviewed the program and helped to select projects, and has semiannually evaluated current research and provided guidance for future research. The committee members appear to be technically knowledgeable regarding the objectives of the research program and its implications for their segment of the industry.

During the first year of the project, a broad examination of each of the major research areas was conducted. The processes were evaluated for likelihood of success, practicability, potential utilization, economy, and productivity and product improvement potential. During the second year, in-depth analyses were performed on nonwoven fabric bonding, film properties for coated fabrics (e.g., leather substitutes), and cellulose fiber flammability. Studies on the bonding of pigment prints and synthetic fiber flammability were discontinued. Crimp stabilization was de-emphasized. Auxiliary studies included studies of resin structural parameters and their effect on final filament properties as well as evaluations of selected processes. On the recommendation of the Advisory Committee, study has since been resumed on pigment printing.

Specific results from the research include significant improvement in film properties for fabric coatings and finishes, improvements in pigment printing, and development of low-volume resin coating techniques.

Utilization Objectives

The potential users of this research on radiation polymerization of resins are of three types: the textile manufacturing and converting industry, chemical manufacturers, and radiation processing equipment manufacturers.

The textile manufacturing industry is characterized by a broad range of vertical and horizontal integration of product lines. There are very large companies that manufacture yarn from natural and synthetic staple fibers, knit or weave these into fabrics, dye and finish those fabrics, and fabricate them into final products such as hosiery, drapery, blankets, sheets, towels, and similar products. Others are diversified to the extent of manufacturing carpets and furniture, as well as chemicals for the textile industry. As a rule, textile companies do not make synthetic fibers, and synthetic fiber manufacturers do not manufacture textile goods. There are many small textile firms which perform only one or a few of the manufacturing steps mentioned above. For example, there are yarn manufacturers, weavers, knitters and fabric finishers. There are also firms, sometimes referred to as converters, that take textile substrates and provide special finishes, coatings, laminations, and other intermediate products for industry and apparel manufacturers. The size of these companies ranges from very large diversified textile manufacturers to small operations with a few knitting machines or a single finishing line. The textile industry maintains a very low level of research in new process technology and depends to a great extent on its machinery and raw material suppliers for innovations, aside from textile product style innovations.

Chemical manufacturers involved with textiles include those from the very largest, such as Union Carbide, Stauffer, Sun Chemical and others, to much smaller firms that buy basic monomers and oligomers and formulate compounds tailored to specific product applications for their customers. There is some parallel in the chemical and textile industries in that there is a broad range of size and degree of specialization. The chemical industry maintains fairly strong research capability and is highly motivated to product innovations. Much of the initiative for development of ultraviolet curable coatings for metal and particle board, as well as curing of printing inks, lies with the chemical suppliers and the radiation equipment manufacturers.

Manufacturers of radiation processing equipment are few, and specialize in this type of equipment. The four companies which are most active in the field currently are Radiation Polymer Company, a Division of PPG Industries; Energy Sciences Corporation; High Voltage Engineering Corporation; and Radiation Dynamics, Inc.

The significance of this research may be viewed from several positions. First, it may be viewed in terms of the significance of the textile industry to the nation; second, it may be viewed in terms of its contribution to the solution of national problems and concerns as they relate to the textile industry; and third, in terms of the impact which this research program may have on the textile industry itself.

The textile industry is a major employer, providing jobs for approximately one million people and contributing about \$30 billion to the economy. As one of the country's basic industries, research which contributes to its well-being should contribute to the national well-being.

National concerns on energy conservation and pollution abatement are also concerns of the textile industry. With respect to energy, for example, the dyeing and finishing segment of the textile industry uses approximately 80 trillion BTU's of energy annually for drying of fabrics or thermal treatment to produce fabric finishes. With respect to pollution, the textile industry emits large quantities of gaseous pollutants that are driven off during thermal reaction of fabric finishes or coatings, and liquid effluents from scouring and dyeing operations. The industry uses conventional pollution control techniques to reduce actual emissions into the environment, but further improvement is required.

With respect to flammability, textile related household fires cause many deaths and injuries each year. Reduction of textile flammability is an important national concern.

The ability of this research to contribute to a basic segment of the industrial economy and to the solution of national needs is not easy to assess. The textile industry is composed of a large number of companies, most of which are relatively small. Even the larger companies have diverse product lines and tend to have a highly decentralized management. This decentralization results in institutional barriers to research and development and eventual adoption of new and innovative processes. As a result, changes in basic processes come about slowly. In contrast, the clothing and home furnishings segment of the industry is fashion oriented, and thus has a continual change in product construction and appearance. These various factors cause most textile firms to depend upon machinery suppliers for innovations in process equipment, and upon fiber and chemical suppliers for innovation in finishes and fibers. The producer of the consumer products thus focuses completely on the market--leaving technology to others.

In light of these factors, research programs that place the textile industry in a favorable competitive posture relative to foreign made products, reduce its energy requirements, and solve some of its pollution and flammability problems, will make substantial contributions to the nation's well being.

Dissemination of research products has been active. The program reports, issued at six-month intervals, fully document the procedures and results of specific laboratory investigations at NCSU. These have been found useful by a number of the textile firms and chemical suppliers. Two seminars on Radiation Processing of Textiles organized by the Principal Investigator, have been conducted at NCSU. Various members of the University staff, outside consultants, and faculty of other universities have participated in these. The seminars have been well attended and well received by industry. Dr. Walsh has also described the work at several technical conferences. As a result of a presentation at the Radiation Curing Conference sponsored by the Society of Manufacturing Engineers, interest has increased to where the Conference will include a session on textile applications at future meetings. Dr. Walsh has also provided consultation and experimentation for several textile firms interested in exploring particular applications.

Utilization Obtained

An attempt was made in the course of this case study to contact most of the members of the Advisory Committee since they are well informed members of the targeted user community. These contacts have revealed much similarity of opinion, but also a divergence on some points. An attempt was

made to query the committee on some of the specific factors related to objectives, such as improved product properties, energy reduction, and pollution abatement; and also to elicit evaluations of the program and its utilization apart from these other stated objectives. Their remarks are as follows:

Research & Development Center
Springs Mills Inc.
Fort Mill, South Carolina

Mr. L. V. McMackin
Finishing Research
Group Leader

Mr. McMackin has been active as a member of the Advisory Committee and has attended all the meetings, participating in the discussions and providing suggestions based on his experience. Springs Mills is not currently using radiation technology commercially, but Mr. McMackin believes that it will ultimately be used by them. They are continuing to follow the field closely, with their main interests being in the pigment printing and flame retardation applications.

Mr. McMackin cited several reasons for the lack of application at Springs Mills. One of these is the lack of resin formulations suitable for their particular requirements. They are not currently working with potential resin suppliers and are not aware of activity by the resin suppliers to provide necessary formulations. He feels that available thermal processes are adequate for current needs. Dr. Walsh's work has demonstrated a technical feasibility for radiation curing. However, the production-scale feasibility must be worked out by the textile manufacturers consistent with their own particular requirements. The lack of available pilot facilities is seen by Mr. McMackin as a factor that will act as a barrier to production-scale development. The cost of such facilities is considered as being prohibitively high. Mr. McMackin sees energy savings as a factor in encouraging use of radiation curing. The cost of energy, even though it may

be readily available, continues to increase and is a real concern at Springs Mills. Also, radiation cured products having properties not obtainable by other processes would encourage adoption of the technology.

Mr. McMackin strongly supports the work that Dr. Walsh has directed and feels that the lack of such basic research capability in the textile industry is a real detriment to furthering the adoption of radiation curing technology. He feels that a joint research effort that serves the industry, such as the NCSU program, is very beneficial; and that a pilot facility available to all the industry for conducting trials would be invaluable for developing utilization. He foresaw one difficulty with this approach--that being protection of the proprietary interests of the various companies that participate.

Burlington Industries
Greensboro, North Carolina

Mr. John Hansen
Research Chemist

Mr. Hansen reported that Burlington had investigated the application of ultraviolet curing in 1973 in their own laboratories, but concluded it was not particularly applicable to textiles due to the lack of penetration in thick substrates. They also felt that during that period, there was a lack of interest in the textile market on the part of the chemical suppliers. Since Dr. Walsh's program at NCSU was just beginning at that time, Burlington expected it to serve the exploratory research needs in the radiation curing field. Burlington has no current commercial applications of radiation curing technology. However, some of Dr. Walsh's recent work suggests that a re-examination in certain areas, such as coated fabrics, is in order.

Mr. Hansen cited a lack of available chemical formulations as a major deterrent to applications at present. He felt that the major suppliers to

the textile industry were not strongly interested in the market. However, some of the smaller custom-formulators are making an effort. A basic technical problem in applying the technology is distribution of small amounts of chemicals, such as finishes, on textile substrates.

Mr. Hansen did not see energy as being a particularly important factor in determining utilization of the radiation technology. Energy costs for finishing operations are not seen as a major factor in the total manufacturing cost, except perhaps where certain multipass transfer coating operations are employed. Neither was he concerned about the availability of pilot facilities. Ultraviolet equipment is inexpensive and readily available. Mr. Hansen cited the availability of electron beam equipment at United Merchants as providing what is currently needed.

Mr. Hansen felt that Dr. Walsh's program had made a major contribution to radiation technology in developing formulations appropriate to coated fabrics and felt that the current research program was adequate and appropriate to the needs of the textile industry.

Burlington Industries
Greensboro, North Carolina

Mr. Clifton Karnes
Director, Corporate Research
and Development

Mr. Karnes is of the opinion that Dr. Walsh and others have made some significant advances in radiation curing technology and that the process potential cannot be ignored. He cited three factors that are essential to commercialization of a radiation cured product:

- . A textile product which has some unique property imparted by the radiation curing methodology;
- . Equipment satisfactory to carrying out the process; and
- . The necessary chemical formulations.

Mr. Karnes feels that Dr. Walsh's program has provided a focus for these factors, and that this continued focus is the major contribution

of the program to the industry. He believes that the primary technical contribution has been in the area of improved properties of coatings and, while Burlington does not currently produce coated fabrics by any process, they will re-evaluate this position in light of Dr. Walsh's work on coating properties.

In discussing factors that might influence the commercialization of the technology, Mr. Karnes cited the reversal of the cotton and polyester fiber price situation in the past few years. Whereas cotton was less expensive than polyester a short time ago, polyester is now the less expensive fiber. Providing adequate finishes for polyester is more difficult than for cotton and, if the current fiber price situation continues, it could have an influence on commercialization of radiation technology.

With regard to energy as a factor in commercialization of radiation curing, Mr. Karnes felt it was a minor factor because the supply of energy for the textile industry has not been a problem so far, partly due to their adoption of coal and oil as substitutes for natural gas. In addition, Burlington's studies have shown that approximately 1/3 of the energy utilized in producing a fabric goes into yarn formation operations, 1/3 into fabric forming operations, and the remaining 1/3 into the dyeing/finishing operations. Of the latter 1/3, only about 20 percent is expended in resin curing operations, amounting to less than 7 percent of the total used. This relegates energy considerations to a minor role in adoption of radiation curing.

On the other hand, Mr. Karnes cited the durability of the bond produced by radiation induced polymerization as a clear advantage of that methodology. With regard to the availability of chemical formulations, he feels that chemical suppliers respond to pressure from the textile industry and that they are not likely to enter the market strongly without such incen-

tive. Because of the complexity of introducing a new technology, Mr. Karnes felt it was difficult to project when any substantial commercialization would occur, but did venture an opinion that a time frame of 5-10 years from now seemed a reasonable projection.

Fieldcrest Mills Inc.
Eden, North Carolina

Mr. William E. VanZant, III
Manager, Finishing Research

Mr. VanZant has been a member of the Advisory Committee and has participated in most of the meetings. He has had additional contacts with Dr. Walsh regarding applications of radiation curing to problems peculiar to Fieldcrest. For example, laboratory experiments at NCSU to investigate radiation curing on nonwovens for blankets and thermal insulation will be conducted in the near future. If successful, they will be followed by further experimentation on the pilot electron beam unit at United Merchants Research Center. Fieldcrest has no current commercial application of the radiation curing process. They are principally interested in it for flocking operations on blankets. They also have some interest in crimp stabilization of carpet yarns.

Mr. VanZant expressed the feeling that Dr. Walsh's work had advanced the radiation curing technology to a more useful level and had provided research and development which would not have been done at Fieldcrest. He feels that while the textile industry as a whole is innovative in styling and product adaptations, it is not innovative in process development. Therefore, the NCSU program has served a useful function.

In discussing factors other than product properties which might influence commercialization, Mr. VanZant felt that energy was not a strong consideration. However, potential restrictions to pollution are definitely seen as a problem. Plasticizers from flock adhesives and finishes on the flock material itself are potential pollution hazards. Elimination of

these through other processes would be advantageous. Another positive aspect of radiation polymerization would be the potential increase in line speeds of that process. However, realization of that benefit would require replacement of current process machinery. Mr. VanZant sees that as an unlikely possibility. Another detriment to commercialization is the lack of pilot-scale facilities for experimentation and the cost of providing such equipment. Renting or leasing of radiation equipment, as suggested by one equipment manufacturer, would be acceptable only when the process is proven and not for high risk development. With regard to the availability of chemical formulations, Mr. VanZant sees no current strong interest on the part of suppliers to provide such products.

Deering Milliken Research Corp.
Spartanburg, South Carolina

Mr. Dmitry Gagarine
Vice President
Chemical Research

Mr. Gagarine has served on the Advisory Committee for the program. Deering Milliken has additionally furnished fabrics and other materials for experimentation during the program. His personal opinion of the program was that it has accomplished a great deal for the textile industry and should be continued. This support is particularly interesting since Deering Milliken was one of the first textile firms to establish and maintain a strong internal research and development organization.

Mr. Gagarine stated that the volume of fabrics produced by the radiation polymerization process has been decreasing recently for several reasons. The process was originally developed to provide durable press and soil release properties and allow Deering Milliken to capture a share of the industrial uniform market. Subsequent developments and improvements of the soil release properties provided by the resins have allowed a continual

decrease in laundering temperatures by the linen suppliers to the point where the properties imparted uniquely by the radiation polymerization are no longer as necessary as when initially introduced. Consequently, Deering Milliken is interested in other applications of the process, such as flocking and improved stiffness properties for carpet fibers and coated fabrics.

Mr. Gagarine cited several technical accomplishments of the NCSU program. These include the determination of sensible thickness of carpeting as it relates to the bending modulus of the carpet fibers. There is an optimal modulus which produces the most satisfactory feel to the carpet, and the work done at NCSU on coating of fibers to produce this optimum is significant. Also, the work done in developing the flame retardation application and in pigment printing is worthwhile. The pigment printing work is significant because the low molecular weight binders used in the radiation cure process tend to encapsulate the pigment particles and eliminate problems common to conventional pigment printing.

With regard to nonproduct factors that may influence commercialization, Mr. Gagarine felt that potential energy savings would be important. For example, they are now producing heavy upholstery fabrics that are difficult to dry due to poor air penetration. Substitution of radiation curing might solve this problem with lower energy use. The cost of resin formulations, which are now about \$2/pound, is also a factor.

The availability of equipment for development purposes is not seen by Mr. Gagarine as a deterrent to commercialization. The equipment is no more costly than conventional thermal processing equipment that textile manufacturers manage to have available for development purposes. Mr. Gagarine felt that instead, the lack of basic knowledge of radiation polymerization technology in many textile firms was the major deterrent to progress towards

utilization. The program at NCSU has provided a substantial degree of this expertise to the industry, and is thus helping to increase their confidence in utilization of the technology.

Since Deering Milliken does not have any solvent processing operation at the moment, except for some dry cleaning, pollution reduction through the use of radiation curing was not seen as a factor in its commercialization.

Union Carbide Corporation
Technical Center
South Charleston, West Virginia

Dr. Kisson Park
Project Scientist

Dr. Park has participated in the Advisory Committee meetings and followed the project closely. He reports that Union Carbide is active in the manufacture and marketing of products for the radiation curing field. They supply photo-initiators, monomers, and formulations for the coating industry. These are principally used in the UV curing of coatings on metal and wood. Union Carbide is interested in the textile market, but Dr. Park projects that a substantial market may not develop until the 1980's. He feels that commercialization in the textile industry requires a textile product with some unique performance advantages which can be attributed to the radiation process.

With regard to the energy question, he feels that energy sources are still sufficiently available and inexpensive, and thus energy is not a factor in utilization. However, the continual upward trend in energy costs eventually will exert more pressure to reduce energy utilization and make radiation curing more attractive. Dr. Park does see the lack of pilot-scale facilities as a real disadvantage in developing applications. The pilot facilities currently being installed by Energy Sciences Corporation will be helpful, but their distant location from most textile manufacturing opera-

tions will be a disadvantage. Union Carbide is in the process of obtaining their own electron beam equipment, which will facilitate their development program.

Dr. Park feels that the NCSU program has encouraged the exploration of applications of radiation curing, but experimentation must be carried beyond the laboratory scale to prove commercial feasibility. Also, the electron beam unit at NCSU is not of the latest design and this has limited the demonstration of certain applications.

Union Carbide has a long-term commitment to develop products for utilization in the textile industry, and this commitment is based largely on long-term projections of energy shortages, according to Dr. Park. They have been working since 1974 to develop chemical products for the textile industry. However, they see the textile industry as a very conservative one, and realize the need for increased cooperation and communication among chemical suppliers, textile manufacturers, and radiation curing equipment manufacturers.

C.L. Hawthaway & Sons Corp.
Lynn, Massachusetts

Mr. Joseph R. Martin
Vice President
Sales Department

Mr. Martin has been a member of the Advisory Committee and participated in its meetings. In addition, Hawthaway has provided oligomers and fabrics for use in research experiments at NCSU. Hawthaway's business is the compounding of oligomers for industry. They are not currently supplying products to the textile industry. Mr. Martin indicated that the transfer coatings application is a good possibility for future development.

Mr. Martin believes that energy savings and environmental pollution regulations will be factors in the acceptance of radiation curing by the textile industry. He also mentioned increased production rates as a

positive factor. With regard to the current cost of chemical formulations for radiation curing, from \$1.50-2.00/pound, the price may potentially decrease to around \$1.00/pound if production volumes increase substantially. Negative factors with respect to commercialization include the cost of equipment and the lack of available facilities for conducting developmental work.

Stauffer Chemical Company
Eastern Research Center
Dobbs Ferry, New York

Dr. Edward D. Weil
Senior Scientist

Dr. Weil is a member of the Advisory Committee and has attended most all of the meetings. In addition, Stauffer has provided chemical formulations to Dr. Walsh for experimentation purposes. Dr. Weil indicated that the Advisory Committee is a good feature of the research and that Dr. Walsh has made good use of the Committee's capabilities.

The major interest of Stauffer in the program is in flame retardation. According to Dr. Weil, they manufacture the only radiation-polymerizable fire retardant currently on the market. This product is now polymerized chemically, but Stauffer is interested in developing the radiation curing method. Dr. Weil believes that the process may be utilized commercially within one to five years, but feels that the timing will be substantially influenced by deliberations of the Consumer Products Safety Commission which is currently considering flammability tests.

Dr. Weil mentioned several factors that will influence commercialization of the technology. For example, low volume padding (padding is the process by which finishes are applied to fabrics) is important in applying radiation curable resins. While low-volume padding is common in Europe where the equipment is available, such equipment is not readily available in

this country. The high processing speeds and lack of cross-linking obtainable with radiation curing are potential advantages. Also, he feels the lower energy requirements, in view of increasing energy costs and service interruptions, will tend to encourage application. With regard to why the radiation curing technology has succeeded in other industries such as metals, wood coatings, and floor coverings, Dr. Weil stated that these are much easier to accomplish because UV curing is used. Resin application to a smooth surface is easier, and the product properties are less demanding than those required in textile fabric.

Dr. Weil feels that the NCSU program has made a substantial contribution in the flammability area by demonstrating the importance of low moisture in the resin and demonstrating feasibility of low-volume applications of the formulations. He feels that the application would be further enhanced by having some pilot process facilities.

Thiokol Chemical Division
Trenton, New Jersey

Dr. Robert F. Hoffman
Director, Research and
Development

Thiokol did not have a representative on the Advisory Committee when it was formed, but has participated for the last year and a half. They have also supported Dr. Walsh by supplying samples of oligomers and monomers for experimentation. Thiokol has been particularly interested in the development of improved film properties, and views the vinyl top-coating of fabrics and application of flock adhesives as potential markets for their products. Currently, they supply urethane oligomers and specialty acrylate monomers to various customers. The textile industry is viewed as a good potential market, but its development has been slower than originally anticipated.

Dr. Hoffman feels that in situations where capital equipment expansions are contemplated, the radiation curing technology should be

attractive. Factors in this decision would be reduced energy consumption, reduced floor space requirements and increased production speeds. Energy availability rather than the cost of energy is seen as the more important factor. In contrasting the textile industry application with that of other industries where the technology has become more widespread, Dr. Hoffman pointed out that most of those applications are UV and not electron beam, so that the process equipment cost is substantially lower than it would be for the electron beam equipment required in textiles. He also noted that the product performance requirements are substantially less.

Dr. Hoffman feels that the NCSU program would be enhanced by having pilot-scale equipment with full process capability in order to demonstrate product and process potential on a more realistic level. He also suggested that a product with good commercial potential be selected and developed as a demonstration of the technology.

Radiation Polymer Company
PPG Industries
Plainfield, Illinois

Mr. Keith Clark
Marketing Manager

Mr. Clark is a member of the Advisory Committee and has been active throughout the project with the exception of the last two meetings. In addition, he has participated with Dr. Walsh in seminars at textile firms by demonstrating the UV curing equipment. Radiation Polymer is a division of PPG Industries which is potentially a supplier of radiation curable resins. Mr. Clark believes that their interest in these materials increased substantially as a result of the Radiation Processing of Textiles short course conducted by Dr. Walsh in May 1976. Mr. Clark is aware of developmental interests by textile firms in UV processing, and has assisted in several tests recently.

Mr. Clark feels that the lack of chemical formulations appropriate to the textile industry is a major reason why the process has not been adopted. He is confident that applications will develop in the textile industry, and cited the example of commercialization of UV coatings on particle board, which required a period of 15 years to develop.

Mr. Clark is very complimentary of Dr. Walsh's program, but suggested it might be improved if more encouragement were given to the members of the Advisory Committee to develop specific applications of interest to them.

High Voltage Engineering Corp.
Burlington, Massachusetts

Mr. Carl R. Hoffman
Sales Manager
Radiation Processing Systems
Industrial Products Division

Mr. Hoffman is a member of the Advisory Committee and has participated in its meetings. High Voltage Engineering supplied the equipment to Deering Milliken for their commercial process. They are currently interested in developing applications of flame-retardant chemicals, adhesives, and fabric printing. Mr. Hoffman feels that the NCSU program has provided a developmental capability to the textile manufacturers with little or no risk on their part, and is thus a useful service. He felt the creation of interest in the technology and dissemination of information was valuable

With regard to commercialization of new processes in textiles, Mr. Hoffman believes the lack of funds for capital expansion in the last year or two has deterred the acceptance of radiation technology, but that this situation is improving. He feels that radiation curing of adhesives for application of flock can be economically justified in situations where the process equipment must be purchased, rather than being run on existing thermal equipment. Operating costs for an electron beam apparatus are estimated by Mr. Hoffman to be \$10,000/year, whereas a gas curing oven may run

\$60,000-75,000/year. He also feels the availability and cost of energy will become increasingly important in the choice of curing methods. Mr. Hoffman remarked that he did not believe the lack of pilot process facilities was a particularly important factor in utilization of radiation.

Radiation Dynamics, Inc.
Westbury, Long Island

Dr. Ken H. Morganstern
Chairman of the Board

Dr. Morganstern has served on the Advisory Committee and attended many of the meetings. He is unaware of any recent application of the technology in textiles except for the pilot facility at the United Merchants Research Center, and feels that the adoption of radiation polymerization by the textile industry has been disappointingly slow. He attributes this to the low level of research and development in the textile industry. Dr. Morganstern feels the technology eventually will be adopted, but could not predict when this might come about.

Dr. Morganstern is complimentary of the NCSU project. He feels that it has been well managed, the participation of industry has been good and that Dr. Walsh has made a good selection of research project areas. Radiation Dynamics is continuing its exploratory contacts with textile manufacturers and sees some further interest in the research.

Features

One of the stronger points of this research is the capability and experience of the Principal Investigator, Dr. William K. Walsh. Dr. Walsh has about 15 years' experience related to the application of radiation to textile products as well as to other aspects of textile polymeric materials. All members of the Advisory Committee contacted in the course of this

investigation spoke highly of Dr. Walsh and of his technical capabilities. Because of his extensive experience in textile research, he communicates effectively with the industrial user community. The School of Textiles at NCSU provides an excellent environment in which to conduct this research program. It offers strong programs in two departments: textile technology and textile chemistry.

The relationship between NSF and NCSU appears to be satisfactory and has posed no problems in the conduct of the research program. The NSF Program Manager, Dr. Aller, is enthusiastic about the program and the performance of the Principal Investigator.

Interaction between the industrial user community and the Principal Investigator has occurred on both a formal and informal basis. The User Advisory Committee has participated in the formulation of the individual projects within the program and has reviewed them semiannually. However, it must be noted that the textile industry is highly competitive and that, consequently, there is a reluctance for competitors to be entirely candid about their new product interests and plans. Such disclosure is not entirely necessary for the purpose of advising NCSU on the conduct of a research program, but frank and open discussion of considerations which could be important to early commercialization of some of the technology is not possible in meetings of this type.

The Principal Investigator does, however, have other contacts with the various potential users and has assisted them in evaluating specific interests on an individual basis. One example of industry interest is found in the Thiokol Company which has provided \$5,000 in additional funding to Dr. Walsh to support his investigations. One of the more important aspects

of user participation in this program has been the opportunity for interactions among the textile manufacturers, the chemical suppliers, and the radiation equipment manufacturers, each of which is an indispensable component in the commercialization of the radiation curing processes. The seminars and user advisory meetings provided a forum for these interactions.

One of the principal barriers to utilization is the availability of commercial processes that produce many of the product properties available with radiation curing. The disadvantages of relatively large energy utilization and of pollution emission inherent in these currently used techniques as compared to radiation processing are not of sufficient concern at this time to justify a switch in process technology. The capital investment required for radiation curing is commensurate with current thermal and chemical techniques; however, the radiation process equipment does not adapt itself to other process uses, such as drying. The technical know-how for using radiation curing does not exist in many textile companies. The low level of research and development inhibits its acceptance. This is in contrast to variations of current chemical or thermal treatments which are very familiar to plant operating personnel and are fairly easy to integrate into existing production facilities.

The accepted practice in the textile industry in developing a new process or product is to conduct process experiments on existing full-scale process equipment and evolve the product through successive small variations. The lack of radiation curing process equipment which allows investigation of process parameters on a production scale is a definite barrier to commercialization. Equipment dedicated to this purpose is now being acquired in two or three companies, (Union Carbide, United Merchants and

Energy Sciences), and its availability will hopefully stimulate experimentation and evaluation of commercially attractive products by both the chemical suppliers and the textile manufacturers.

However, the major barrier to commercial utilization, cited by industry representatives, is that the unique properties attributable to radiation curing are not sufficient to economically justify the investment at this time.

Conclusions

With a few notable exceptions, the textile industry is a fragmented industry with a low level of process research and development expenditures. It is felt that this research program has been utilized in terms of influencing these companies' current activities; but in the case of United Merchants, this has not been established. The research program described in this case study has been well-conceived to augment that research capability in an area of relatively high-risk, long range research that would not otherwise have been conducted by the industry itself. The program still has its third year to be completed, and in this year, emphasis is on applications assistance to industry.

This research is focused on national needs associated with energy, productivity, pollution, flammability and, in particular, to strengthening the basic competitive position of the textile industry. Its successful utilization ultimately lies in the commercial application of the research, and this appears to be moving rather slowly. For example, Deering Milliken has had a commercial process since the mid-1960's, but has not expanded the

process to product lines beyond the original one; and Bixby International, a manufacturer of shoe linings, has recently installed a radiation-cured flocking operation, but report they were motivated more by space requirements in an existing plant facility than by the process itself. Whether Bixby is a member of the textile industry, and thus a target of this research, is open to discussion; but the most likely answer is that they are not a part of the textile industry. Nonetheless, they may be considered a user of the research. Important factors inhibiting greater utilization include:

- . The cost of capital equipment and the specialized nature of that equipment;
- . The need to define viable commercial products whose properties depend on use of radiation curing; and
- . The lack of compelling energy or pollution incentives, despite the current national concerns over these issues.
- . While capital costs are not higher than conventional process equipment, the conventional equipment is already in place.
- . Electron beam equipment does not have multiple uses as does thermal process equipment.
- . There is a reluctance to invest in a new process unless the resulting product has been fully explored and proven.

Even though laboratory work on radiation processing has shown promise, equipment for full-scale development is not readily available to test variability in the product. This should be overcome with pilot facilities operating at production speeds. Products with properties not attainable from conventional processes need to be identified and developed. There is a divergence of view about the incentives furnished by energy availability,

but these may be short- rather than long-term views. Short-term, however, the need for energy reduction appears limited and of small general concern.

Perhaps the greatest value so far in the program has been to provide a focus on the technology and continued development in a high-risk area, so that as conditions become more favorable, the industry will be in a position to adopt this technology. It is clear that there is activity of a research or developmental nature in several companies (Union Carbide, Thiokol, Deering Milliken, Burlington, Fieldcrest, United Merchants, Energy Sciences, among others) that has certainly been influenced by this research program. In this sense, the rate of use of the technology being investigated has been increased. The utilization of this research program, in terms of commercial production being the culmination of the utilization process, is very limited at present.



RANN UTILIZATION EXPERIENCE

CASE STUDY NO. 41

AUTOMATED BENDING SYSTEM FOR THE FABRICATION OF SHIP FRAMES (Update of Case Study No. 5)

CASE WESTERN RESERVE UNIVERSITY

41-1

Case Investigator:

R. Donovan

Research Triangle Institute
P.O. Box 12194
Research Triangle Park
North Carolina 27709

Technical Reviewer:

D. Wright

Department of Mechanical Engineering
Duke University
Durham, North Carolina 27706

Prepared under:

Contract No. NSF-C76-17165
National Science Foundation
Research Applied to National Needs
1800 G Street, N.W.
Washington, D.C. 20550

Prologue

This case study is an update of a previous NSF/RANN case study of the same title that was issued in June 1975. The presentation here, however, is complete in itself, repeating much of the previous study so that it can be read without reference to the earlier version. The principal technical developments that have occurred between the publication of the two case studies are:

- 1) All grant work has now been completed and published by the Case Western researchers.
- 2) The asymmetrical beam bending problem has been solved and demonstrated.
- 3) Hardware and software for high aspect beam bending has been designed, constructed and demonstrated.
- 4) Transducers for measuring out-of-plane deformation (in order to calculate corrections in the separation angle) have been shown to be unnecessary for all test bends made in the laboratory.

Utilization of the research results has also progressed:

- 1) Funding of the construction of full-size equipment based on the Case Western research is now planned by the U.S. Naval Sea Systems Command, pending acceptance of terms by National Steel and Shipbuilding Corporation, the shipyard at which the Navy proposes to break in the equipment. (The Maritime Administration previously had planned to play the dominant role in the commercialization of the beam bender. Their plans to build one or more shipyard-size models for field use have been dropped because of funding limitations.)
- 2) Hyde Products, Inc., Westlake, Ohio, has been granted exclusive license to build and market the equipment.

The original NSF/RANN project has now been successfully completed. Present activity centers on the commercial utilization of the research results and the measurement of its impact upon a national need.

AUTOMATED BENDING SYSTEM FOR THE FABRICATION OF SHIP FRAMES (Update of Case Study No. 5)

Introduction and Summary

The objective of this research project is to develop a computer controlled method for the cold forming of ship frames, especially large steel beams. The approach taken is to develop a bench-scale model of a beam-bending apparatus that can: (1) shape ship frames by applying mostly pure bending moment to the members, i.e., a four-point bending action instead of the conventional three-point bending; (2) use computer control with feedback to carry out the bending, including corrections for springback; and (3) eliminate out-of-plane deformation by built-in computer routines that correct incipient errors detected during the bending. The apparatus must be capable of bending beams with either symmetrical or asymmetrical cross sections. It should bend ship frames faster, more accurately (with reduced out-of-plane deformation), and less destructively (with reduced residual shear forces in the bent member) than existing methods.

The successful completion of the project and the attainment of these goals has the potential of revitalizing U.S. shipbuilding, because the frame-formation step affects the costs of all subsequent building steps. At present, shipbuilding is a customized process; all additions to the basic frame must be individually fitted to that frame. Variations in bends and out-of-plane deformations demand costly accommodations in all subsequent operations and have led to the growth of "ship fitting" as a major trade specialty in shipyards. Improved frame bending could, therefore, have a major impact on the total cost of building a ship. Final judgment on this impact will require

evaluation of commercial-scale equipment in a shipyard.

The Principal Investigator for this project is Dr. H. W. Mergler, Department of Mechanical Engineering, Case Western Reserve University, Cleveland, Ohio. Dr. Mergler and associates D. K. Wright, T. Kicher, and M. Savage, along with various graduate assistants, began this research in August 1972 with an 18-month grant from the National Science Foundation Research Applied to National Needs Program (NSF/RANN) for \$148,000.

Subsequent grants of \$84,000 and \$94,000 (this last grant was jointly funded by the Maritime Administration) enabled Case Western Reserve researchers to complete the project in July 1976. Project information is detailed in table 41-1.

This RANN project contributes to the maintenance of a viable U.S. shipbuilding industry which, by Congressional direction in the Maritime Act of 1970, is a national interest. Conceivably, the product of this research could be shipbuilding equipment of such impact that not only would the U.S. shipbuilding industry benefit substantially from its availability, but worldwide interest could lead to U.S. leadership in the limited international market for beam bending apparatus. Two vendors--neither of which is a U.S. corporation--supply the world's needs at present. The advances and advantages incorporated in the Case Western beam bender are such that it could easily wrest the world market from these existing suppliers, leapfrogging the United States from being a non-supplier of ship frame bending equipment to the dominant position in that industry.

Table 41-1
PROJECT INFORMATION

Project Title An Automated Bending System for the Fabrication of Ship Frames via Self-Adaptive Computer Control	Grant/Contract No. GI-35994
RANN Program Manager Dr. Bernard Chern	RANN Program Area Production Research and Technology
Principal Investigator(s) Dr. Harry W. Mergler	Schedule Start: Aug. 1972 End: July 1976
Institution Case Western Reserve University University Circle Cleveland, Ohio 44106	Funding NSF: \$279,000 Other: \$ 47,000 (MARAD)
Contributors/Collaborators D. K. Wright, Case Western Reserve University T. Kicher, Case Western Reserve University J. Garvey, MARAD M. Savage, Case Western Reserve University W. Kosci, Case Western Reserve University D. Braun, Case Western Reserve University A. D. Gresler, Case Western Reserve University	
User Advisory Committee 1) Steinbrenner, American Shipbuilding 2) Society of Naval Architects and Marine Engineers (SNAME), panel review at Case Western, Jan. 1974. 3) High interest & input from Scandinavian Shipbuilding Industry	
Precursor Activities Prof. Mergler became aware of the need during a sabbatical in Norway. While one student did a doctoral dissertation in the general bending methodology, not until RANN funded the research did Dr. Mergler succeed in establishing his program.	

Project utilization is already significant in that a Federal agency, the Maritime Administration (MARAD), has jointly funded the third and final Grant required to complete the research. The U.S. Navy is considering the placement of a full-scale automated beam bender in one of its contractor's shipyards, the resulting production economies being returned to the Navy by way of reduced costs of those ships already contracted for delivery. Such developments have attracted widespread industrial interest and the attitudes of industry are being modified through awareness of the ultimate potential of the Case Western technology.

Utilization of a full-size beam bender by a shipyard is the next step in the development of the beam bender. All technical problems raised by the user community have been solved. However, the beam bender is a sizable piece of equipment and will require a large investment which is proving to be an obstacle for the U.S. shipbuilding industry in the economy of the 1970's.

To take the lead in making the transition from the existing laboratory model to a full-scale production model, Case Western Reserve University has granted exclusive license for marketing and manufacturing to Hyde Products, Inc., Westlake, Ohio. The problem facing Hyde is obtaining the first sale. Having an organization committed to making the research output a commercial reality attests to the technical success of this RANN/MARAD project.

Research Description

The discussion in this section deals primarily with the research on beam bending technology. Since commercial beam benders are available, it is imperative to review the basic and important differences between those and the newly developed Case Western beam bender.

Traditionally, the method used to form bent members for ship frames has been to fit each newly bent member to a precut wood or plastic template. More recently, many beam benders use the method of straightening out the inverse of the desired bend, which has been chalked from a template onto the member to be bent. This innovation eliminates the need for full-scale templates. However, both methods are trial-and-error, requiring skillful operators to produce accurate results within a reasonable time. A second, more critical disadvantage of both present systems is the use of a three-point bending method. Such a scheme causes large shear stresses and, consequently, undesirable twisting and out-of-plane bending. Out-of-plane deformation is especially acute in bending beams with asymmetrical cross sections.

The technique developed by Dr. Mergler and his associates at Case Western Reserve University avoids both problems. The Case Western technique depends upon what is essentially a four-point bending action to achieve zero shear force bending over the bulk of the bend. It relies upon independent control of the plane-of-moment application and feedback corrections in order to avoid out-of-plane deformation.

The forces and moments associated with the two basic bending methods are sketched in figures 41-1 and 41-2. The conventional three-point bending produces shear forces throughout the bent member; the four-point loading achieves zero shear forces (i.e., constant bending moment) along most of the bend, a highly desirable feature in bending.

In pure bending, the beam is gripped at two points and bent (exerting pure moment forces on the beam), as shown in figure 41-3. In the idealistic case, there is zero shear force over the entire length of the beam. In the realistic

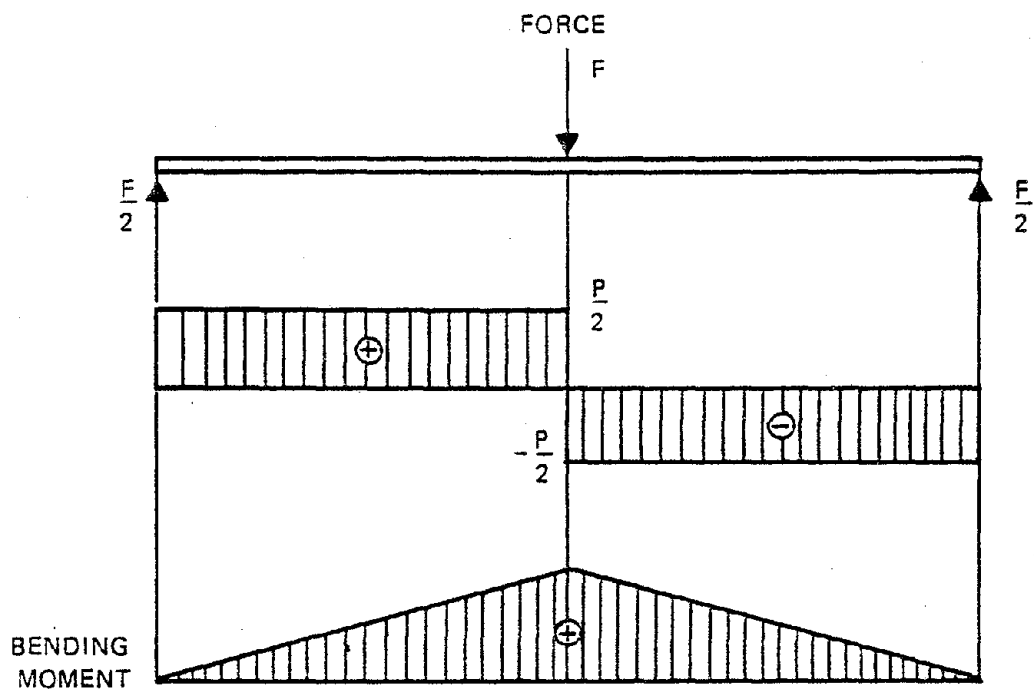


Figure 41-1. Traditional Three-Point Bending.

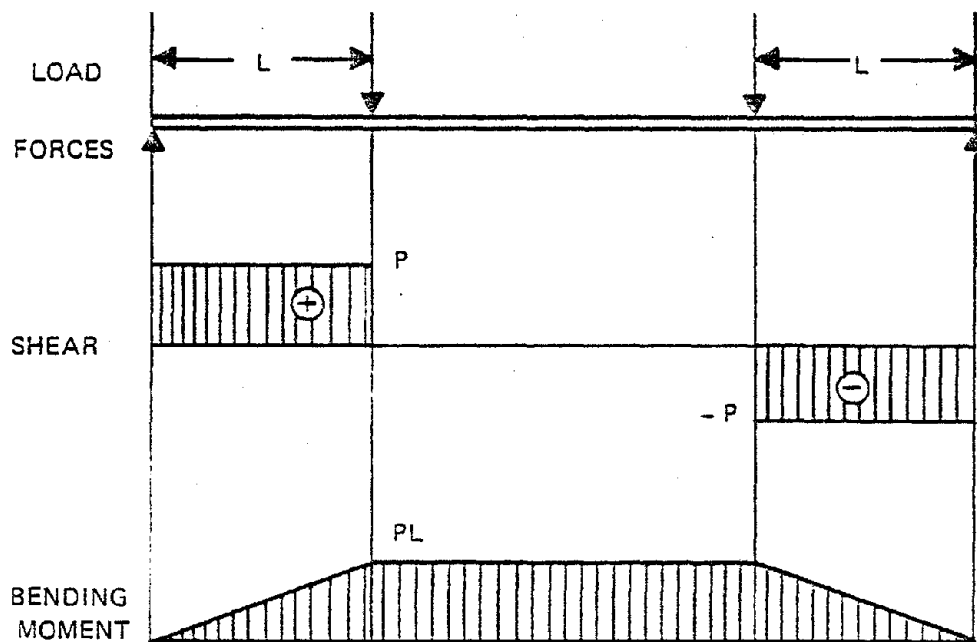
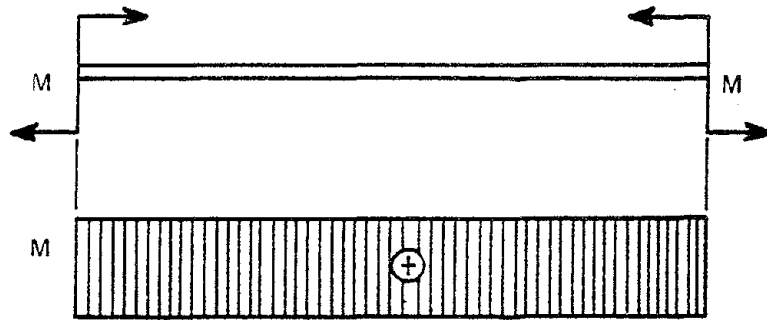
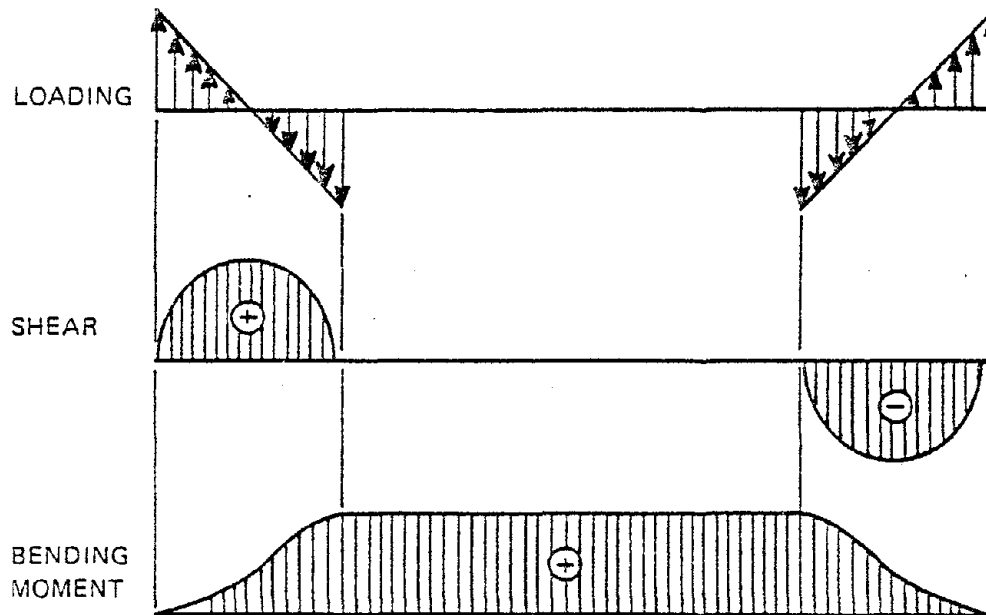
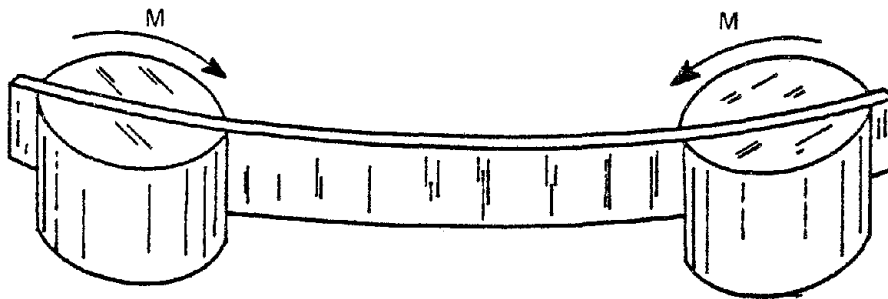


Figure 41-2. Four-Point Bending



a) Idealized pure bending.



b) Realistic "pure" bending.

Figure 41-3. Pure Moment Bending.

case, a finite gripping area is needed so that in this region, shear forces do exist and the bending is equivalent to four-point bending rather than to the idealized pure bending case illustrated in figure 41-3a.

To minimize the out-of-plane deformation that is unavoidable in bending beams of asymmetrical cross section with conventional equipment, the Case Western bender has the capability of separating the plane-of-moment application from the desired plane of deformation. These concepts are illustrated in the cross section of an angle beam in figure 41-4. The plane in which the moment must be applied in order to avoid out-of-plane deformation does not coincide with the principal axis of the beam. To bend the angle beam in the plane of the major web, the moment must be applied in a non-obvious plane as illustrated. In bending this beam with the Case Western machine, a calculation of the separation angle between the two planes is made before bending. Once the bending is underway, corrections in the separation angle can be made as needed to eliminate out-of-plane deformation. Conventional beam benders do not have this capability and, when bending beams of asymmetrical cross section, they attempt to minimize out-of-plane deformation by clamping two or more beams together to form a composite member of symmetrical cross section. When unclamped, the forces change after bending, necessitating additional corrective action. The newest three-point bender (the Pullmax-Ursviken frame bender, manufactured in Sweden, Appendix D) allows bending in two perpendicular planes so that out-of-plane deformation can be partially removed by a compensating bend. Older benders require remounting of the beam for the restoring bend. Common practice is to ignore it and rely on compensation during ship assembly.

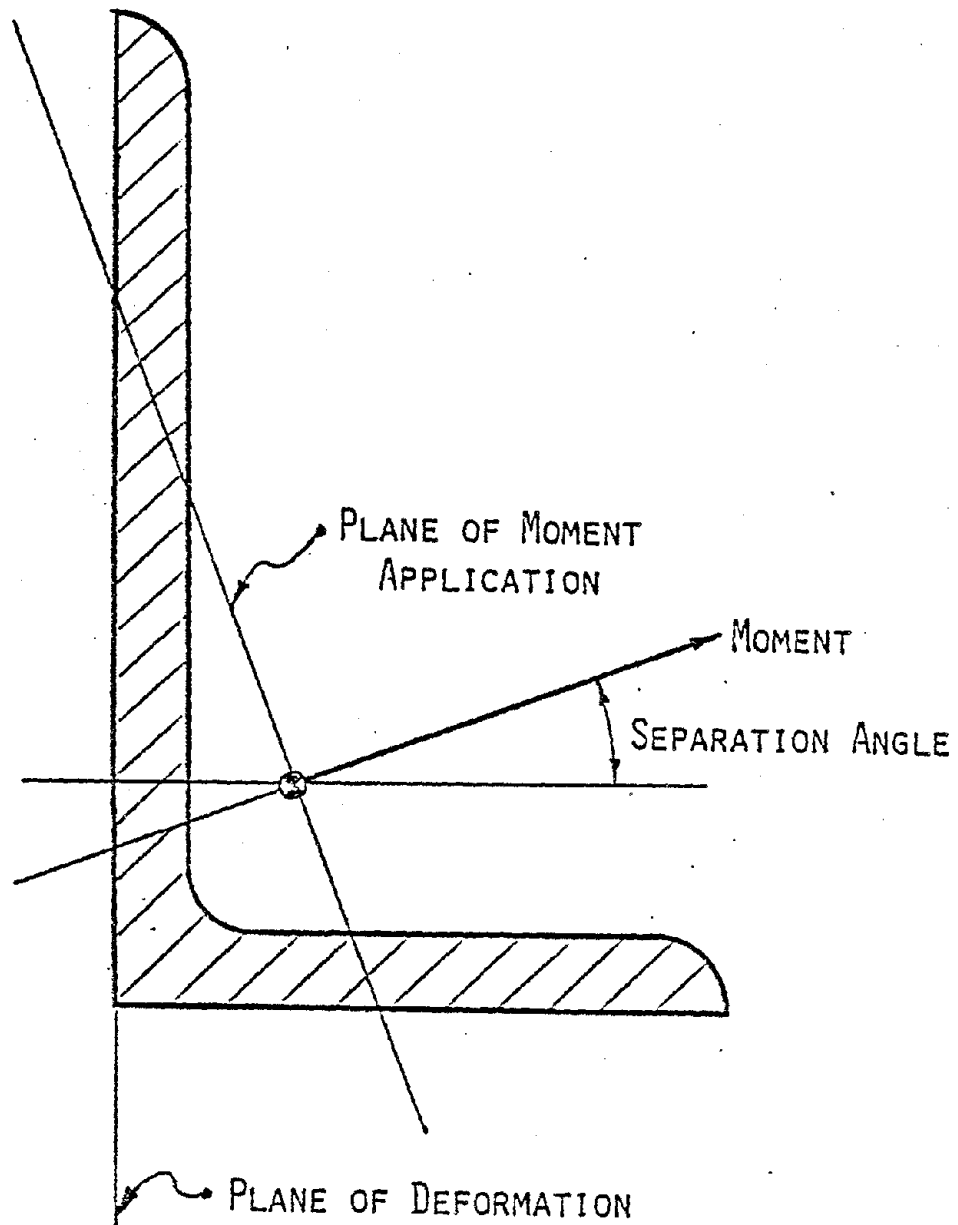
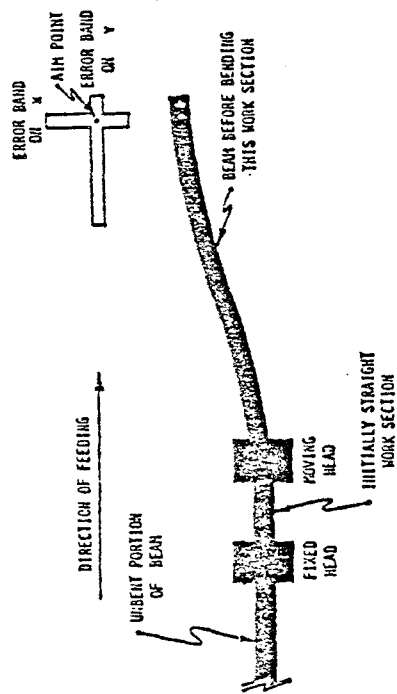


Figure 41-4. Separation Angle for an Angle Cross Section

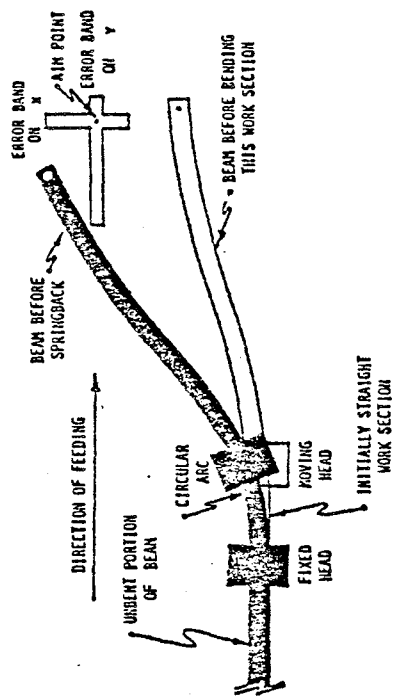
The key control feature of the Case Western bender is its self-adaptive operation, which directs the bending and uses computer-controlled feedback to continuously correct for springback. Out-of-plane deformation could also be corrected by feedback, but present thinking is that this routine is unnecessary because initial calculations of separation angles have proven adequate to effectively eliminate out-of-plane deformation. Therefore, the expense of the necessary additional hardware and software on a commercial beam bender does not seem justified at present, particularly in view of the fact that an operator can adjust the separation angle manually to correct any incipient out-of-plane deformation. Such corrections have not even been necessary on those asymmetrical beams bent in the laboratory.

The present computer routines are: (1) compute the desired position of the end point of the beam; (2) drive the end point to its proper "y" coordinate, including a springback correction that is checked after each bend; and (3) once the "y" position is satisfactory, translate the beam end to the desired "x" position.

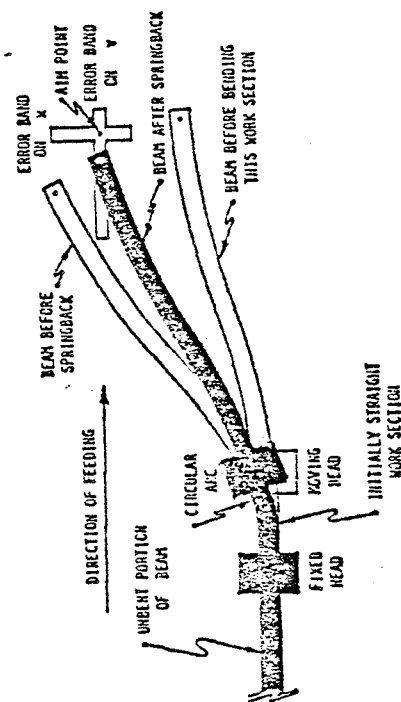
These actions are summarized in the plan views of figure 41-5. The bending moment to any beam is applied by two gripping heads, one of which is fixed and the other of which is movable. The beam inserted in figure 41-5 has already been bent (the section to the right of the gripping heads). All new bending takes place along the straight section between fixed and moving heads as in figure 41-5a. Two displacement transducers are mounted on the dot at the end of the beam to read out the (x, y) coordinates of that position. The computer calculates the desired position of the dot after bending--the aim point. The computer then directs an overbend (figure 41-5b) so that after springback, the



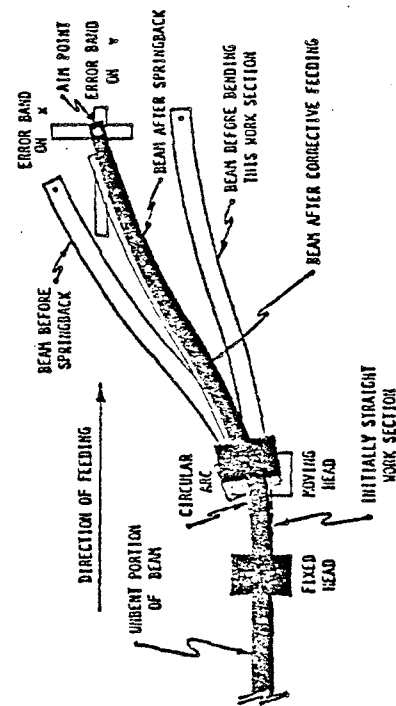
(a)--Initially Straight Work Section



(b)--Bend Including Springback Estimate



(c)--Springback within Error Band on Y



(d)--After Corrective Feeding to Aim Point

Figure 41-5. Proceedings of a Single Work Section

"y" position may require several iterations and the calculation of a revised springback correction. Once the "y" position is satisfactory, the feed mechanism simply advances the beam to the desired "x" position.

The result is a machine that incorporates state-of-the-art computer technology in order to upgrade the beam-bending operation to a faster, more accurate process that is free of many previously unavoidable human errors. At the same time, the machine employs principles of mechanics, made practical by the improved electronic control, that produce a structurally superior bend. The research has progressed to the point where transfer to industrial users is the next major step.

The product of this research is a general method for bending beams or other forms into desired complex shapes. The developed process employs computer control and feedback, which promises to make the bending operation inexpensive, accurate, and rapid. A laboratory model, pictured in figure 41-6, was designed to bend scaled down ship frame members. This laboratory model consists of the hardware illustrated plus the computer software needed to carry out automated bending. At the suggestion of shipbuilders, who have provided the major user input, techniques for bending beams of high aspect ratio (beam width \approx 40 times beam thickness), without beam buckling, have been developed and successfully demonstrated.* All needs cited by the shipbuilding industry have been

* Although not yet described in the thorough detail characteristic of the published Case Western work, the method consists of rigidly clamping the beam so as to confine all displacement to the place of deformation. The clamp design is not trivial since it must move with the bending beam without restricting the bending. The third and final report in the frame bender series (Part III, now in press) reviews the design and test of these anti-buckling clamps.

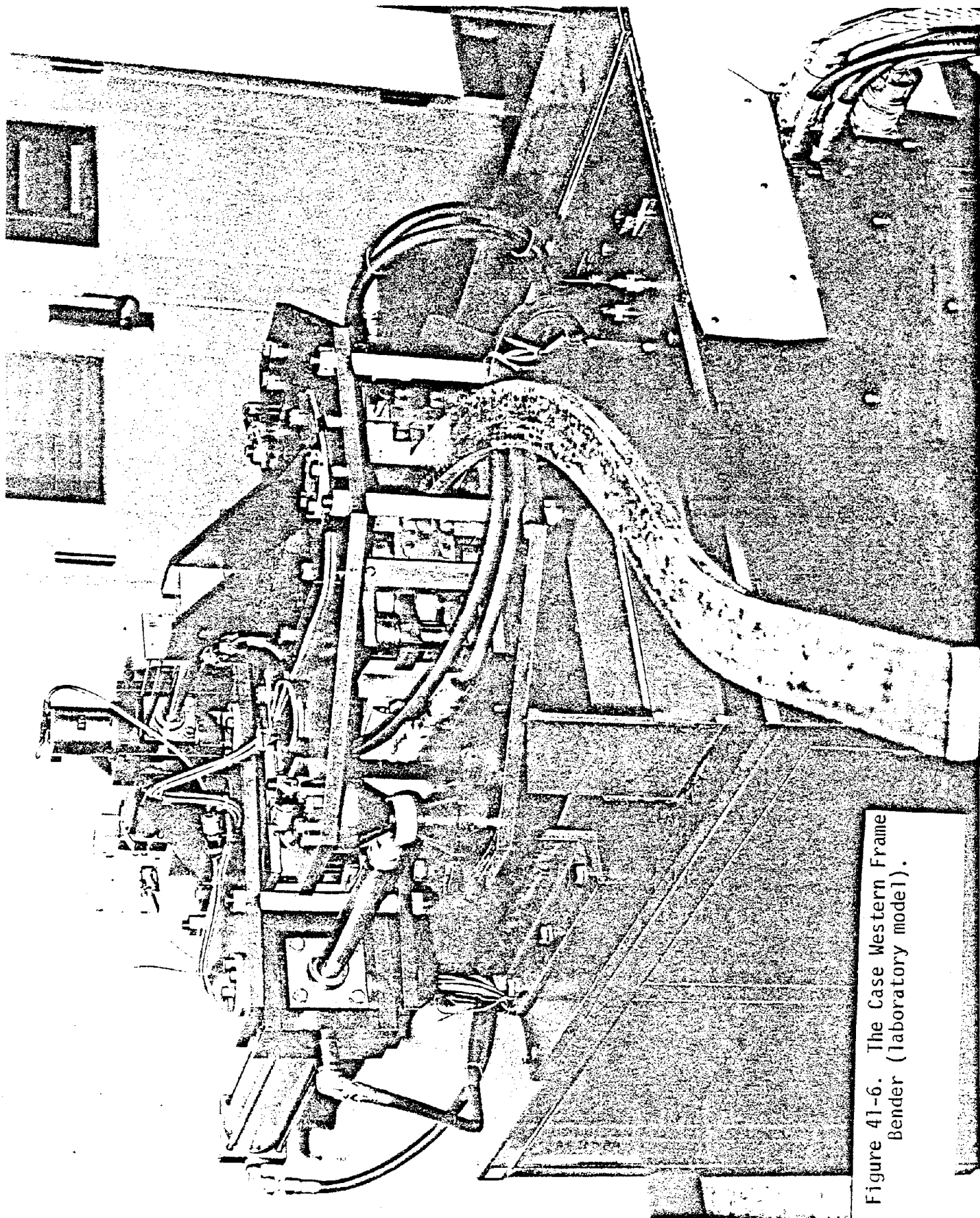


Figure 41-6. The Case Western Frame Bender (laboratory model).

met. Technically, the project is now an unqualified success. No shipyard is yet using the apparatus, however, which is the prime utilization objective.

In the approach initially proposed by Dr. Mergler, the costs of computer-controlled bending were to be directly compared with the costs of the frame-bending operations presently used in shipbuilding. This comparison has not been made because the accounting procedures of most shipyards do not lend themselves to pinpointing with any accuracy the costs of individual operations or procedures. Therefore, a reliable cost comparison is extremely difficult to obtain and only estimates are available for assessment. This limitation will hinder adaptation of the equipment in the highly cost-conscious shipbuilding trade, simply because a convincing case for the magnitude of cost savings to be gained by using the improved bender becomes more difficult to present.

At the urging of NSF/RANN, Dr. Mergler prepared comparative cost estimates for three methods of ship frame fabrication, including cold bending by the Case Western method. His estimates are summarized in table 41-1 and are detailed in figure 41-7.

The estimates in figure 41-7 do not include: (1) costs of scrap produced by method 2; (2) rework costs during ship assembly associated with methods 1 and 2; (3) template storage costs or the facilities for template fabrication and frame marking; and (4) cost of computer facilities for incorporating AUTOKON* in method 3. A complete cost analysis, if available, would probably indicate a much larger cost savings for method 3. Again, these cost estimates are probably controversial and would vary from shipyard to shipyard. The

* For explanation of AUTOKON, see Appendix C.

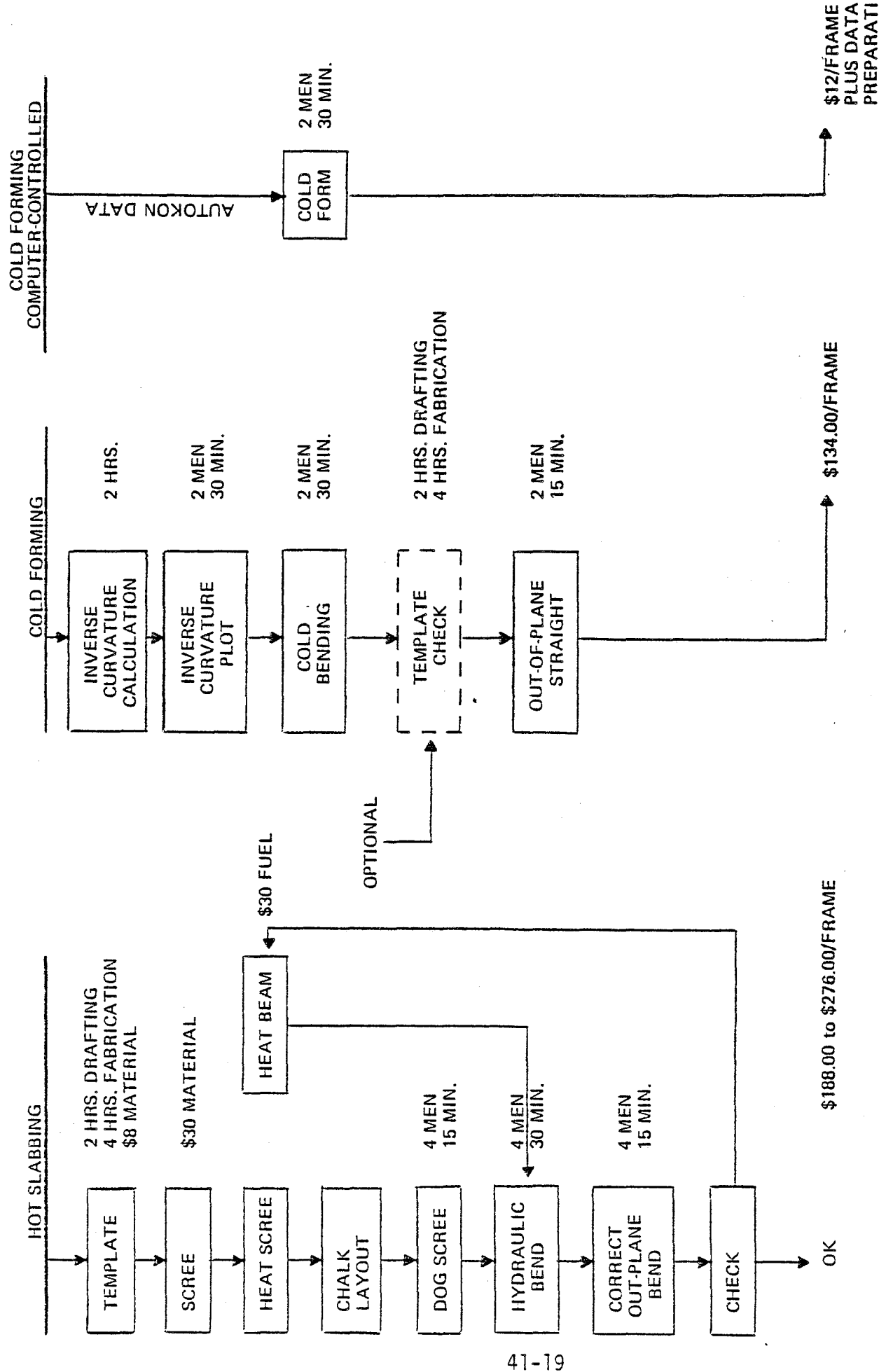


Figure 41-7. Estimates of Comparative Ship Frame Processing Costs.

conclusion that the Case Western method costs less initially and in operation would probably not be seriously challenged; that the savings would be as great as estimated by Dr. Mergler might provoke some skepticism.

Unpublished analyses by the National Steel and Shipbuilding Company in San Diego, however, tend to support the general conclusions of Dr. Mergler's economic analysis. This shipyard is a leading candidate for being the site at which the full-scale bender first enters service. The technical/economic justification of an automated beam bender is well established with respect to their operations. This justification depends only on production economies in beam bending and beam straightening. If a ship has 4500 beams, perhaps 10 to 15 percent of them (for a Navy ship) are curved. Many of the remaining straight members must be welded, which often entails a subsequent straightening operation. While the beam bender pays its way on bending beams alone, its ability to straighten deformed or sagging members is likely to be a significant bonus.

Table 41-2. Summary of initial and operating cost estimates of three methods of ship frame fabrication

	<u>Method 1</u>	<u>Method 2</u>	<u>Method 3</u>
	Hot slabbing (the old method)	Manual cold-forming (Pullmax-Ursviken method) [†]	Computer-controlled cold forming (the Case Western method)
Capital costs	\$150,000	\$175,000	\$125,000
Operating costs to bend a 25-foot section	\$188 to \$276*	\$134*	\$12*

[†] Appendix D

* Itemized costs appear in figure 41-7.

If in addition, the beam bender produces a ripple effect in cost reduction, e.g., a much decreased cost of ship fitting, its impact could be much greater than that from reducing costs only in the bending/straightening process. The Case Western beam bender produces bends in beams with heretofore unachievable accuracy and reproducibility. Shipbuilding could become more of an assembly of accurately fitted, preshaped parts, as in an automobile assembly line, rather than the custom fitting process that it is now. This possibility could have major economic consequences. The present custom fitting involves hydraulic jacks, which slowly force members into alignment one at a time. No estimate of the cost reduction resulting from the minimization or elimination of custom fitting now exists. Reliable measurements should become available during shipyard evaluation.

Utilization Objectives

The immediate utilization objective is to build and operate the first full-scale model in a shipyard. The performance of this equipment will define the long-term objectives in the shipbuilding industry and will also help focus on related industrial bending problems.

Utilization Obtained

Utilization to date has been at the planning level only of various user organizations; no full-scale hardware based on the Case Western Reserve design yet exists. The work at Case Western responded to a national need to strengthen U.S. shipbuilding. The prime users to be discussed in this report are from that industry. Many other opportunities for industrial applications exist, a few of which are also reviewed here.

Federal Agencies

The Maritime Administration (MARAD) sponsors the development of improved methods of shipbuilding within subsidized U.S. shipyards in order to improve shipbuilding capability and lower production costs. The automated beam bender fits the criteria for MARAD involvement. NSF/RANN invited MARAD to participate in the beam bender development from the beginning. MARAD helped evaluate the initial Case Western proposal and has been active in the program ever since.

At present, MARAD is "promoting" the acceptance of the bender. In 1975, MARAD considered funding the construction of one or more full-scale models for shipyard use. Subsequently, the agency has retrenched to the point of being willing only to cost-share the construction of production hardware. It would be willing to underwrite non-recoverable engineering costs for the machine construction, but thinks the hardware itself should be paid for by the user shipyard (estimated cost of about \$300,000). MARAD has had no takers.

Mr. Jack Garvey of MARAD is a very active promoter on behalf of the Case Western beam bender. He sees the development as "an economic bonanza for shipbuilding." He has played a principal role in interesting both the National Steel Shipbuilding Company and the U.S. Naval Sea Systems Command in the potential of the equipment. His enthusiasm for the project proves highly contagious.

Mr. Garvey was the MARAD technical monitor for the last phase of the research at Case Western which was jointly funded by NSF/RANN and MARAD.

U.S. Navy

Under their manufacturing technology program, the Naval Sea Systems Command can fund full-scale demonstrations for shipbuilding. At the request

of MARAD's Mr. Garvey, they evaluated the beam bender development as a candidate for support. In the words of Mr. Thomas Draschil, Program Manager, Manufacturing Technology, Naval Sea Systems, "We think it's a very good thing and hope we can follow through on its development and construction." Their plan is to build a full-scale model which National Steel and Shipbuilding Company will use as government furnished equipment. In return, the Navy would receive reduced prices on those ships it now has on order with NASSCO, the amount of the reduction corresponding to the cost savings attributable to the automated beam bending. The details of this arrangement are yet to be worked out. More importantly, the approval of their Fiscal Year 1977 budget, which includes these funds, must precede any further action.

Shipbuilding Industry

The U.S. shipbuilding industry has followed the Case Western work with considerable interest and has been an active participant in it from its inception. A representative from American Shipbuilding Corporation participated in the review of the initial proposal, providing a critique which modified the approach. The Principal Investigator has continuously sought input and critique from the shipbuilding industry, in both the United States and Europe. Shipyard representatives have attended demonstrations at Case Western Reserve at which the scale model performed cold bending operations typical of frame bending for ships.

In January 1974, a panel of the Society of Naval Architects and Marine Engineers (SNAME) held a meeting at Case Western Reserve primarily to review the beam bender research. Representatives of Sun Shipbuilding, Bethlehem Steel, and Newport News Shipbuilding and Drydock Company participated in the meeting. In addition, the minutes of the meeting were forwarded to other

panel members, including representatives from Bath Iron Works, Seatrain, National Steel, Quincy, Ingalls Shipbuilding, and Marine Industry, Ltd. These shipbuilders have followed the research with varying degrees of interest since this meeting. Most take a wait-and-see attitude because capital investments of the magnitude required for a beam bender are not made frivolously (some shipyards have never bought one).

Over the past year, National Steel and Shipbuilding Company, at the urging of MARAD's Mr. Garvey, completed an internal analysis of the cost effectiveness of an automated beam bender for their operations. According to Mr. James Acton, facilities planner for NASSCO, they are "thoroughly convinced it's the best machine available" and can justify its acquisition based on production economies in beam bending and straightening alone. Any cost reduction because of reduced subsequent shipfitting is a bonus and is not included in their assessment.

Mr. Acton's cost estimates agree reasonably well with those previously prepared by Dr. Mergler (see figure 41-7). Bending costs should be reduced by a factor of 10.

The NASSCO Naval Sea Systems Command plan, whereby the Navy buys the production bender and cost savings are returned to the Navy, will result in the generation of valuable, publicly available, cost data. These data should be very persuasive in promoting more widespread use of the beam bender.

Hyde Products Inc., a subsidiary of Zimmite Corporation, is located in the Cleveland suburbs. It specializes in custom machine design and construction. The principals of the organization have backgrounds in shipbuilding and know the industry and its people. Because of their familiarity with shipbuilding, they reacted swiftly to a press release from Case Western Reserve University which described the work of Dr. Mergler and his group on the automated beam

bender.

Upon receipt of an exclusive license to market the beam bender, Hyde Products paid all filing fees and legal expenses needed to obtain patent rights in the name of the Case Western researchers. Their exclusive, eight-year license to manufacture and sell the beam bender extends to October 1983, although it contains a clause of revokability if no manufacturing occurs during the first three years (to October 1978).

Mr. Thomas Mackey, General Manager of Hyde Products Inc., sees the key advantages of the Case Western bender (now the Hyde Frame Bender, Appendix E) as production savings because of its automation, its high accuracy in bending and its compatibility with AUTOKON or any other numerical control software. Its price tag will be no more than that of similarly sized Ursviken or Hugh Smith (a Scottish manufacturer of beam benders) machines.

Incurrence of some engineering costs (\$60,000 to \$100,000) before construction of the full-scale production unit remains inevitable. Most likely, these will be covered by the proposed plan being considered by the Naval Sea Systems Command and NASSCO. The time scale following a go-ahead should be on the order of:

3- 4 months, developmental engineering
14-16 months, building
2 months, debugging and delivery
19-22 months total

The machine assembly is simple. It requires no long lead-time items, the electronics package being built from essentially off-the-shelf components.

Hyde clearly considers the Navy/NASSCO program their best chance to break into production. They are not, however, standing idly by while that procurement plan runs its course. They are actively promoting interest among smaller, nonsubsidized shipyards and are seeking applications of the control methodology

in industries other than shipbuilding. A market survey is now underway to identify the most promising of these other applications.

Other Potential Users

Numerous inquiries have been received and fielded by Dr. Mergler in regards to applying the beam bending methodology to other industrial tasks. Dr. Mergler routinely responds with as much information as the inquirer wants.* His group has prepared a proposal to study the potential applications of their bending methodology as a tool for general shaping operations in the field of nuclear power generation. This proposal was submitted in response to a request from a builder of power generating equipment. It was not accepted because the potential sponsor chose to pursue an alternate method. The beam bender first came to this potential sponsor's attention from the Case Western presentation at the NSF Grantee Conference at Stanford University in 1974. After review of the proposal, he concluded the method was close to solving his proprietary problem, but he decided not to invest in it.

Formation of valve seats for use in the fabrication of huge (10" to 60" at present, eventually 10-foot) tri-centric (butterfly) valves is another potential application of the method. This valve design is based on a foreign patent. Because it incorporates a metal-to-metal seal, it is satisfactory for high temperature operation and could be useful in the nuclear, petroleum and chemical industries for controlling large flows of hot, high pressure fluids.

*Dr. Mergler laments his inability to accurately forecast costs associated with providing this necessary follow-up service. Such "technology transfer" services have made significant demands on his time and budget, for which he now has no mechanism of recovery. He is resigned to continuing to provide this invaluable service, but urges other Principal Investigators and their RANN Program Managers of successful research projects to anticipate these costs and allow for them in order to lessen this "price of success."

The Case Western beam bender has successfully bent flat bars into the preforms needed prior to rolling them into a specially shaped valve seat. The valve seat could actually be a section cut from a cylindrical pipe at 10 degrees from the perpendicular. Because of their size, this is not a practical method of making the valve seats and the Company makes preforms which are rolled into the desired shape. In the judgment of Mr. Harry Jackson, Manager, Manufacturing Engineering, Clow Corporation, the Case Western beam bender made more accurate preforms faster than their present technique based on using a template. His company is impressed by the method and may be a customer within two years.

Other applications, for which inquiries have been received, include beam bending for mine roof support and intricately-twisted reinforcing rods for complex concrete structures. No firm follow-on activity has yet occurred in these areas, although Hyde Products, Inc. has prepared a solicited proposal to build the equipment required to bend the large reinforcing rods used in the construction of nuclear power plants. Shipbuilding itself has applications for the methodology beyond frame bending (such as bending hull plates or the numerical control of pipe bending).

Features

A major factor fostering acceptance of the Case Western beam bender is the early and continued interaction with the prime user, the shipbuilding industry. The Principal Investigator has solicited and given thorough consideration to input from all the users he could identify. This development has not been carried out in isolation. A significant portion of the research has been devoted to identifying user needs that would make the development

most valuable to shipbuilders. All technical objectives of the research, both as originally conceived and as modified to include user recommendations, have now been met. The universal praise accorded the development by the user industry reflects the thoroughness with which the needs of that industry have been considered. The industry/academic barrier has been surmounted, largely because of the attentive ear of the Principal Investigator and his willingness to accommodate the demands of a real-world application.

Even so, the accommodation may not be reciprocated--at least not on the same time scale. The total world population of beam benders in the shipbuilding industry is about 120, of which 10 to 15 percent are of the relatively new Pullmax-Ursviken type SBRP. Mr. A. Schmidt of Western Gear, the U.S. representative for the Pullmax-Ursviken machine, estimates that the worldwide market for beam benders between now and 1980, consists of about 25 sales of which no more than six will be in the United States. If, as seems likely, the Case Western beam bender phases in as replacement equipment, this is the size of the prospective shipbuilding market. Those shipyards that have invested in the Pullmax-Ursviken will be slow to replace it. Mr. G. Falt, Harding Plant Manager of the Bath Iron Works, did not even attend the Case Western demonstration in 1974, simply because there is no possibility that Bath will replace its Pullmax-Ursviken machine in the foreseeable future.

The impact of more accurate, shear-free bends upon total shipbuilding costs is yet to be demonstrated. Consequently, the user experience with the full-scale model, hopefully to be built and put in shipyard service by the U.S. Navy, will be valuable in more clearly establishing the total impact of the Case Western beam bender upon overall shipbuilding costs. Shipbuilding is traditionally a conservative industry. It will not embrace this new technology without thorough evaluation.

The addition of Hyde Products , Inc. to the team greatly enhances the likelihood of effective utilization of this NSF/RANN supported research. The Hyde organization brings a very important element into the utilization plan--a professional marketer whose own profit/loss statement can be significantly influenced by the commercial success of the beam bender. The staff at Hyde, well-versed in shipbuilding operations, is enthusiastic about the potential impact (and market) of the beam bender. Their willingness to invest their time (and dollars, to secure the patent rights for Case Western Reserve University) is sincere testimony to their belief in its value. They appear to be the right organization at the right time for bringing the commercial version of the research into being.

While the major role in the beam bender program has now shifted to Hyde Products, Dr. Mergler continues to be an ever present force. Promoting utilization of successful research and development can be a time-consuming and financial burden upon the Principal Investigator and his organization. Such efforts are left largely to the "good graces" and charity of the performing organization. Happily in this instance, Dr. Mergler continues willing--if somewhat resignedly (see footnote, p. 41-26), to aid the utilization cause of his research and promises to be deeply involved in the steps remaining in successful utilization.

Successful utilization of the beam bender appears now to be more a matter of "when" rather than "if." All potential shipyard users who have reviewed the work are complimentary of it and come away impressed with its capability. Both the Maritime Administration, which has already invested in the development, and the Navy, which may soon invest in it, regard the development highly. Hyde Products is anxious to start producing it. There is not a dissenting vote in view. With such support, it is difficult to believe that the present funding barriers will prevail much longer.

Conclusions

The overall experience appears to be a good example of how NSF/RANN should respond to national needs. Representatives of the user industry--in this case, a government agency, the Maritime Administration, in addition to shipbuilders--participated in the initial planning, and the subsequent execution benefited continually from review and critiques by user groups. The development became of sufficient interest and practicality to warrant joint funding by the Maritime Administration. Tentative plans now exist for the Navy to assume funding responsibility for the initial full-scale, industrial application.

The user industry is aware of the development and exhibits various levels of receptivity, closely tied to the costs. If the beam bender is as successful in reducing the labor involved in shipbuilding as has been forecast by its developers, it will have profound effects on the shipbuilding industry. The requirements for various labor skills could be changed and the design of ships would be affected by the new economies.

Technology transfer is a frustrating, unpredictable activity at best. The elements that came together in this case to produce a textbook illustration of how it can be done are not easy to enumerate exhaustively or with confidence. However, they include: NSF/RANN's close identification with the user group or industry from the proposal stage on; the researcher's competence, as well as his adaptability and diplomacy (almost certainly a researcher will be required to adjust to the requirements of the users rather than vice versa); and the interest

and financial support of another government agency with responsibilities in the field, and interests of the user group.

Successful technology utilization is not an exact science. What works in one case may be totally inapplicable in another. In spite of the difficulties in defining the elements that make up successful technology utilization, it is relatively easy to recognize it when it occurs. This case study, though descriptive of an activity not yet consummated, shows all signs of being an outstanding example of successful utilization. This optimism is shared by researchers, sponsors, and users.

Appendix A

Sources of Information

Dr. Bernard Chern
NSF/RANN Project Officer

Dr. Harry W. Mergler
Case Western Reserve University
Principal Investigator

Mr. John J. Garvey
Manager, Shipbuilding Research
Program
Maritime Administration
Department of Commerce
Washington, D.C. 20031

Mr. Thomas E. Draschil
Program Manager, Manufacturing
Technology
Naval Sea Systems Command
Code 03541
Washington, D.C. 20362

Mr. James B. Acton
Facilities Planner
National Steel and Shipbuilding
Company
P.O. Box 80278
Harbor Drive at 28th Street
San Diego, Ca. 93128

Mr. R.E. Thomas
Manager of Production Engineering
Newport News Shipbuilding &
Drydock Company
Commercial Ship Division
Newport News, Va. 23601

Mr. Filippo Cali
Cali & Associates, Inc.
3101 37th Street
Metairie, La. 70001

Mr. E. Lacrosse
Sun Shipbuilding
Chester, Pa. 19013

Dr. Bernard Breen
General Dynamics Corporation
Groton, Conn. 06340

Mr. Al Schnidt
Product Manager
Shipyard Equipment
Western Gear Corporation
2100 Norton Street
Everett, Wash. 98201

Mr. Joseph F. Szoo
Project Manager
Production Technology Section
Westinghouse Research & Development
Center
1300 Beulah Road
Pittsburgh, Pa. 15235

Mr. W.A. Conrad
Plant Engineer
Sun Shipbuilding
Foot of Morton Avenue
Chester, Pa. 19013

Mr. David B. Dunlap
Assistant Superintendent in charge
of Special Projects
Bethlehem Steel Sparrows Point
Shipyard
Sparrows Point, Md. 21219

Mr. Gordon H. Falt, Jr.
Harding Plant Manager
Bath Iron Works
700 Washington Street
Bath, Me. 04530

Mr. Svein A. Hansen
Senior Consultant
Shipping Research Services, Inc.
205 South Whiting Street
Alexandria, Va. 22304

Mr. Frank McConnell
Manager of Process Engineering
Ingalls Shipbuilding
P.O. Box 146
Pascagoula, Miss. 39567

Thomas P. Mackey, Jr.
General Manager
Hyde Products, Inc.
810 Sharon Drive
Westlake, Ohio 44145

Mr. Jack C. McVickers
Director of Production Technology
Westinghouse Research and
Development Center
1300 Beulah Road
Pittsburgh, Pa. 15235

Mr. H.A. List
Senior Research Engineer
Mill Equipment and Control
Bethlehem Steel Corporation
Bethlehem, Pa. 18016

Mr. Harry C. Jackson
Manager, Manufacturing Engineering
Clow Corporation
P.O. Box 205
Westmount, Illinois 60559

Mr. Robert W. Helman
Supervisor
Homer Research Laboratory
Bethlehem Steel Corporation
Bethlehem, Pa., 18016

Appendix B

Reports and Publications

"Automation in Shipyards: First the Frame" (10 min, 16 mm sound and color film produced for NSF/RANN by Image Associates, Wash., D. C.)

"Dear Factory: Make 100,000 Widgets," MOSAIC, Vol. 5, No. 4 (Fall 1974), pp. 2-8.

Roy Doornbos, "AUTOKON 71, An Overview," presentation to the 10th annual meeting of the Numerical Control Society, New York, April 1973.

Roy Doornbos, "The AUTOKON System, A Short Survey," Shipping Research Services, Inc., 205 South Whiting Street, Alexandria, Va. 22304.

H. W. Mergler, et al., "The Mechanical Development of a Ship Frame Bender in Scale, Part I," June 1974, extract of thesis of Wieslaw Kosci, NSF Grant GI-35994, Digital Systems Laboratory, School of Engineering, Case Western Reserve University, Cleveland, Ohio 44106.

H. W. Mergler, and D. K. Wright, Semi-Annual Progress Report on An Automated Bending System for the Fabrication of Ship Frames via Self-Adaptive Computer Control, March 1, 1973 to August 31, 1973, NSF Award No. GI-35994, Division of Solid Mechanics, Structures, and Mechanical Design, School of Engineering, Case Western Reserve University, Cleveland, Ohio 44106.

H. W. Mergler and D. K. Wright, Semi-Annual Progress Report on An Automated Bending System for the Fabrication of Ship Frames via Self-Adaptive Computer Control, September 1, 1972 to February 28, 1973, NSF Award No. GI-35994, Division of Solid Mechanics, Structures and Mechanical Design, School of Engineering, Case Western Reserve University, Cleveland, Ohio 44106.

H. W. Mergler, D. K. Wright, T. Kicher, and M. Savage, "Computer Controlled Cold-Forming of Ship Frames," report prepared for the NSF Industrial Automation Conference, Stanford Research Center, March 27, 1974, NSF Grant GI-35994, Case Western Reserve University, Cleveland, Ohio 44106.

H. W. Mergler, et al., "Self-Adaptive Computer Control of a Ship Frame Bending Machine, Part II," March 1976, extract of thesis of Donald C. Braun, NSF Grant GI-35994, Digital Systems Laboratory School of Engineering, Case Western Reserve University, Cleveland, Ohio 44106.

- D. C. Braun, and H. W. Mergler, "The Case Western Reserve Computer-Controlled Frame Bending Machine," paper presented to the REAPS Technical Symposium, Palm Beach Shores, Florida, June 24-25, 1975.
- H. W. Mergler, D. K. Wright, D. C. Braun and A. D. Gresler, "Computer-Controlled Ship Frame Bending Machine," Third NSF/RANN Grantees' Conference on Production Research and Industrial Automation, Oct. 1975, Case Western Reserve University, pp. 9-21.

Appendix C

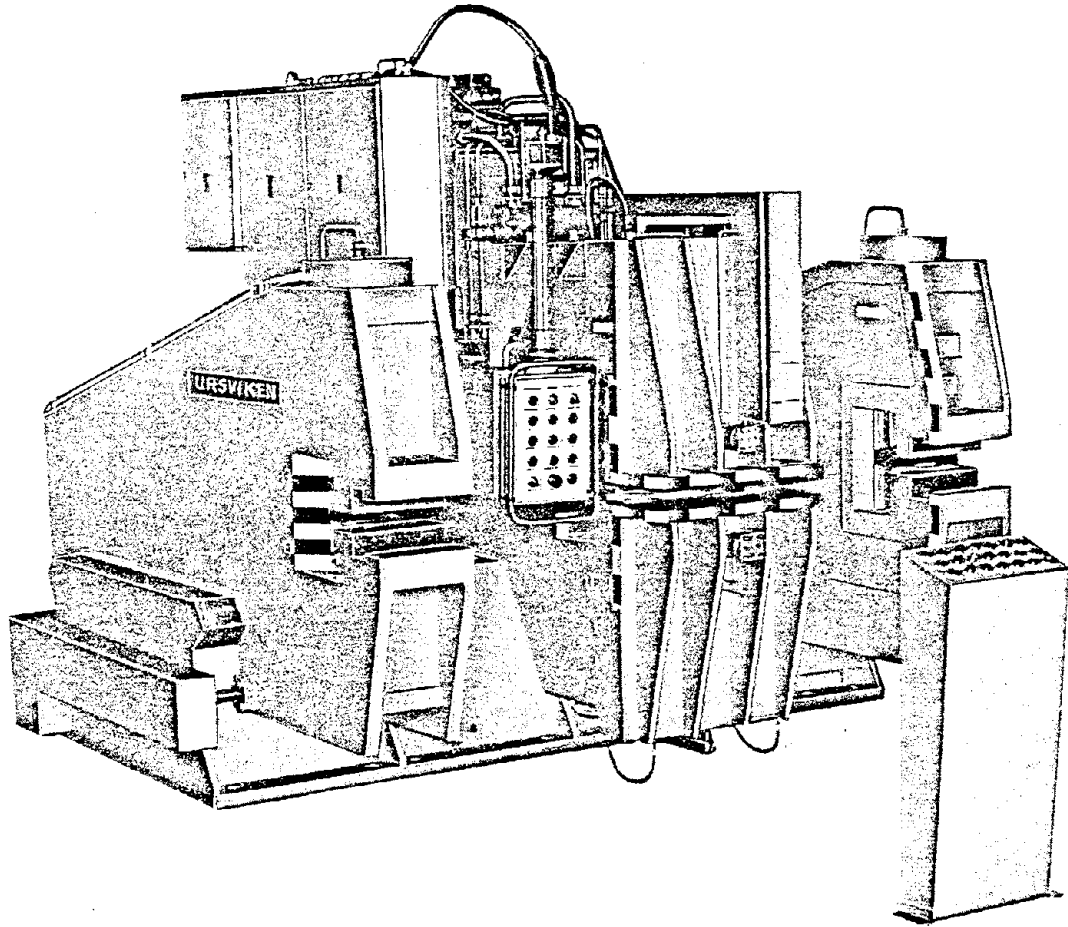
Description of AUTOKON

AUTOKON is the name of a computer-based system, developed in Norway, for integrating the diverse shipbuilding operation into a coordinated, centrally controlled plan that contains the design information and routines for generating anything from technical sketches and inventory records to machine or equipment instructions. The AUTOKON system is continually evolving and expanding, but already has removed much human error from the shipbuilding process. The Case Western frame bender has been built to interface with the AUTOKON software and, hence, is compatible with the trend toward numerical design and control; that is, the Case Western frame bender will bend frames to specifications stored in AUTOKON. It can also be used independent of AUTOKON with independent software.

AUTOKON is not the only shipbuilding system in use, but the Maritime Administration has bought it, as have several leading American shipbuilders. The compatibility of the Case Western frame bender with AUTOKON should enhance the value of the Case Western bender to present AUTOKON subscribers. Conversely, dramatic success on the part of the Case Western machine will enhance the popularity of AUTOKON.

Appendix D

Pullmax-Ursviken Beam Bender



Frame Bender type

SBRP

WESTERN
GEAR CORPORATION

**Heavy Machinery
Division**

2100 NORTON STREET
EVERETT, WASHINGTON 98201
PHONE (206) 259-0922

- 4-way bending and straightening in the press means less handling of the work-piece.
- Feeding without slipping due to clamp feeding system.
- Small radii can be obtained as the work-piece is held by two clamps.
- Easy to operate from a control desk with push buttons and scale on the front.
- Block hydraulics mean simple service, less piping, elimination of the risk of dirt entering the system, and good rigidity.

Appendix E

Hyde Products Press Release

**HYDE
PRODUCTS
INC.**



Established 1895
Subsidiary of Zimmite Corporation

NEWS RELEASE UPON RECEIPT

December 9, 1975

Contact: Thomas P. Mackey, Jr.
Hyde Products, Inc.
810 Sharon Drive
Cleveland, Ohio 44145

Tel: (216) 871-4885

NEW COMPUTER CONTROLLED SHIP'S FRAME BENDER

AVAILABLE FROM HYDE PRODUCTS

Hyde Products, Inc. a Cleveland based manufacturer of ships' deck machinery and marine pollution control equipment has recently concluded a license agreement with Case Western Reserve University, also of Cleveland, for the manufacture of a patented ships' frame bender. The frame bender was developed by CWRU under a grant from the National Science Foundation which was sponsored by the Maritime Administration.

The Hyde Frame Bender is a patented device which uses a unique "four point" bending process rather than the "three point" method normally employed for cold bending of heavy sections. The "four point" method involves the application of pure bending moment to the section being bent. The moment is developed through the application of equal and opposite couples on either end of the section. The use of pure moment bending permits the separation of the plane of moment application and the plane of deformation. This allows the design of a machine with the unique capability of bending beams with symmetrical and non-symmetrical cross sections without out-of-plane deformation. Another advantage of this unique bending process is the uniformity of the bending moment and the absence of shear forces in the bent section of the beam which means no twist or distortion in the bent section.

-continued-

The Frame Bender can be built to handle structural shapes or fabricated sections up to 48 inches deep. Using special stabilizers, even very high aspect ratio sections (e.g. 40 to 1) can be bent without buckling or distortion. The machine is compact and relatively lightweight as no massive foundations are required due to the pure moment bending principle and the absence of shear forces which have to be resisted in conventional machines.

Purchase and installation costs of the Frame Bender are expected to be competitive with other types of frame bending machines.

From the beginning, the Hyde Frame Bender was designed to operate under computer control and to interface with the standard shipyard automation programs such as Autokon. Standard numerical inputs are used and operation of the machine is totally automatic. The Frame Bender may also be set up for manual operation by simply flipping a switch.

Speed of operation is a function of the accuracy required. Normally the bends can be made to an accuracy of 1/32" with only two attempts at each work section. Greater accuracy can be programmed into the machine, if desired.

The beam is fed through the machine automatically. Work section length, indexing and accuracy of the final bend are controlled automatically by the computer program. Variations in physical properties are compensated for in the iterative bending process.

The Hyde Frame Bender may also be used to straighten frames which have been distorted due to the thermal stresses during fabrication or uneven loading during storage.

The Hyde Frame Bender has obvious advantages over the traditional method of bending frames, furnacing and manual bending using sledge hammers. It also has a number of significant advantages over conventional "three point" frame benders. Labor is significantly reduced. No templates are required. Layout and checking time is eliminated. The accuracy of the resultant bend is no longer a function of the skill and perseverance of the operators. Because of the greatly increased accuracy, steel erection time is reduced and the full labor saving potential of the shipyard automation program is realized.

The Hyde Frame Bender has excellent repeatability insuring fast and economical production and minimized quality control problems and costs. The production rate of the machine is, of course, dependent on a number of parameters and conditions, but it can be reasonably stated that production of single frames on a Hyde Frame Bender will significantly exceed the attainable rate on a "three point" bender, even when it is processing two frames at a time back to back.

For further information contact Hyde Products, Inc., 810 Sharon Drive, Cleveland, Ohio 44145.