INTERACTIVE INFORMATION ENVIRONMENTS: A PLAN FOR ENABLING INTERDISCIPLINARY RESEARCH

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A RAND NOTE

INTERACTIVE INFORMATION ENVIRONMENTS:
A PLAN FOR ENABLING INTERDISCIPLINARY RESEARCH

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This Note is an adaptation of a proposal submitted to the National Science Foundation (NSF) for the development of a research methodology to study the process of implementing interactive information environments in information-intensive organizations. It describes early ideas about the methodology and current plans for the establishment of an institute for Interactive Information Environments.

For the past few years, Rand has carried out a large-scale investigation of the implementation of computerized information systems in private sector organizations. Funded by NSF, the study identified major factors affecting the incorporation of information technology into white-collar work. The emphasis was on learning how choices made in planning and executing the implementation of these systems influenced individual and organizational outcomes. Not surprisingly, characteristics of both the organizational context of the intended application and the technology choices influenced the outcome in significant ways. However, the most important discovery was that the implementation process itself had the greatest effect.

In order to investigate this phenomenon more completely, in February 1983 Rand began a pilot project to introduce the generic use of electronic messaging throughout the corporation. It was recognized that electronic messaging is fundamentally a new form of communication, and whenever such significant changes are introduced to a sociological system--such as an office environment--serious and potentially disruptive changes are likely to occur. To forestall disruption and gain the advantages that have been widely heralded under the banners of office automation and productivity enhancement, Rand chose to form an interdisciplinary team of engineers and social scientists to manage the project and supply the innovation required to propel the project to success.

One year later, RandMail was formally inaugurated and installed on all of the corporation's UNIX computers. Use of electronic messaging is growing, and the early signs of organizational change are evident. The
strongest lesson from the experience of this project has been that, despite the abundance of written material on the subject, very little is known about how to successfully implement new forms of communication technology in information-intensive organizations.

In view of this paucity of knowledge, Rand suggests the formation of an Institute for Research on Interactive Information Environments, to be funded by a broad cross-section of industry and government. The objectives of the institute will be to provide the much needed interdisciplinary research on the implementation of computer and communications systems and to make the resulting knowledge widely available.

This Note describes our early planning for the institute as well as our current views of its organization and the research methodology it will employ.
SUMMARY

In recent years, public and private organizations have acquired electronic information tools at an unprecedented rate. This trend is a function of both technology push and demand pull. First, rapid technological advances have removed most barriers to using computers and communications systems for information-handling work. Second, while white-collar work has become increasingly labor-intensive and costly, white-collar productivity has slackened. Consequently, organizations have invested in advanced information technology in the hope that it would enhance the effectiveness of management, professionals, and support staff. These benefits have proven elusive. Computer use has made some activities more efficient, but the dramatic improvements expected from the Office of the Future have not materialized.

The disjunction between technical capability and organizational benefit provides an incentive to carry out research on technological innovation in organizations, with potential contributions to both science and application. Rand is planning a research agenda aimed at understanding and improving the implementation of innovative information technology in organizational settings. Implementation is the focus of this research. Rand's current NSF-supported work on multifunction interactive systems as well as other research on innovation has established that implementation processes strongly influence the outcomes of technological innovation efforts.

Our goal is to establish a continuing program of research on interactive information environments with collaborative support from Rand, government agencies, and vendor and user industries. We will also explore arrangements for participation by university researchers whose work is relevant to the planned agenda.
THE RESEARCH CHALLENGE

Rand's research on technological innovation suggests the fundamental reason why innovative information technology has failed to achieve industrial objectives: organizations have dedicated technology to specific functions instead of using it to create interactive information environments that enhance the generic information handling and communications function of white-collar work.¹ We define an interactive information environment as one that:

- Includes an interactive interface to a computer(s).
- Allows users to access specific applications or databases.
- Lets them exchange information in a system congruent with organizational structure, task demands, and human communications skills.
- Increases individual and organizational productivity by enhancing memory, reasoning power, and communication.

We believe that the full potential of electronic technology can be realized only in the context of well-implemented interactive information environments. However, establishing such environments presents a considerable challenge. Research to date has not adequately explored the concept of interactive information environments in field settings. Rand's office automation pilot project has attempted to improve the effectiveness of communication and information handling activities in the corporation, using an experimentally developed interactive computer system and field trials. However, in general, research has not addressed the question of how to design and implement interactive information environments in varied user contexts.

The studies to be undertaken will both refine that concept and develop an innovative research methodology tailored to the definitive characteristics of information technology. One of the most challenging characteristics of information tools is that they are context-specific. Although the generic functions of an interactive information environment can be defined, a prototype system uniformly applicable to every setting

¹ The relevant Rand studies are described briefly in Sec. VI.
has not been devised. In order to be effective, computer-based technology must adapt to the information and communications systems of specific organizations and to individual users in these organizations, even as organizations must change to accommodate new technology. For this reason, research focused on implementing innovative technologies must consider not only their technical potential and problems but also the organizational context that will dictate the configuration of the information environment.

NATURE OF THE PARADIGM TO BE DEVELOPED

Given the nature of interactive information environments, we believe that the approach for studying their implementation should be characterized by:

- Problem-focused real-time field investigation that moves from prototype development through adaptive implementation processes to sustained assessment of the environments that result.
- Collaboration among disciplines (behavioral and technical sciences), among sponsors (industries, research institutes, and government agencies), and among stakeholders (vendors and users of computer-based information systems).

We plan to apply this approach in a program of pilot projects focused on industrial priorities, using actual settings in sponsoring organizations. Both vendor and user organizations should participate in defining the research process and make use of research products, with the research team acting as the linking agent.

Exploring such a paradigm will contribute substantially to knowledge about implementation processes and about research and development methods for addressing them. Within the framework of an Institute for Interactive Information Environments, research projects using this paradigm would:

- Demonstrate the generic role of interactive information environments for enhancing white-collar work.
• Transfer research knowledge from computer and behavioral sciences, in integrated and usable form, to organizational settings.
• Improve implementation capability and stimulate related technological innovation in vendor and user industries.

The general form of the research program we seek to explore is analogous to procedures employed by NSF-sponsored collaborative research centers and to Rand's private sector sponsors research agenda. However, the planned program is unique in its reliance on field investigation of implementation processes and in the special relevance of collaboration among vendors, users, and research institutions for this purpose.

OBJECTIVES OF THE PLANNED RESEARCH

In order to explore and develop the paradigm, the planned research will have the following objectives:

1. To analyze industrial research and development issues related to interactive information environments, generating a preliminary set of hypotheses about the implementation process and suggesting strategies for testing these hypotheses.
2. To develop a collaborative research procedure for conducting such investigations and for ensuring the scientific quality and usefulness of the results.
3. To directly involve the organizations most likely to use the results in the research process itself, as sponsors and participants, to enable its self-sufficient continuation.
4. To establish communication procedures among participants that will promote (a) interactive specification of research objectives and processes and (b) evaluation and dissemination of results.

We expect to undertake activities for achieving Objectives 1 and 2 with government research support. Objectives 3 and 4 are central to the establishment of an ongoing institute and will be supported by Rand.
The Rand Corporation is unique in its ability to field strong multidisciplinary teams and to undertake serious, unbiased policy-relevant research. It has an unsurpassed reputation for objective research with industry, government, and academic institutions. Moreover, in recent years, Rand has demonstrated its ability to attract private sector sponsors and carry out multi-sponsor research agendas. It currently has two private-sector, multi-client research programs and the management and fiscal arrangements in place to support them. For all these reasons, Rand is especially well-suited to carry out the planned research explorations.
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I. INTRODUCTION

RATIONALE FOR THE PLANNED RESEARCH

Electronic information tools are being introduced throughout white-collar work at an unprecedented rate. The move toward advanced office systems--long predicted--has been spurred by recent technological developments, including the rapid evolution of integrated circuits, the proliferation of portable modular software applications, and sharply declining costs for computation, memory, and storage.\(^1\) Computing power per unit of cost has increased tenfold every four or five years,\(^2\) prompting most large and many smaller organizations to plan for or to attempt to implement automated office technology.\(^3\) By 1990, 50 million U.S. office employees are expected to be using 38 million workstations.\(^4\) In addition, the search for faster error-free communication and the growing need to link information processing systems to large or remote databases and other equipment have created a burgeoning demand for information network technology.\(^5\) For example, a recent forecast from International Resource Development, Inc. (1981) projects that local networks alone will represent a $3.2 billion market by 1990. Many analysts cite changed communications media as the most distinctive feature of the office of the future.\(^6\) Summarizing these developments, Harvard Business School's Richard Walton (1982) calls information technology "the most dynamic sector of technical innovation."

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1 Leinweber, 1981.
2 Walton, 1982.
5 Bikson, 1981.
6 Keen, 1982; Olson and Lucas, 1982.
While the move to advanced information systems in U.S. organizations reflects technological opportunity (*technology push*), it also represents serious cost and productivity concerns (*demand pull*). White-collar workers now constitute over half the U.S. labor force and account for $1 trillion, or roughly 70 percent, of industry's annual payroll. Further, office work is becoming increasingly labor-intensive and costly in most organizations. For example, in 1980 the cost of office operations amounted on average to about half of corporate indirect costs, and these costs are expected to increase about 16 percent annually. Concurrently, growth rates for white-collar productivity have decreased considerably, both absolutely and in comparison with rates for agriculture and manufacturing. The present growth rate for office-worker productivity is estimated at between 0.4 and 1.3 percent per year—in marked contrast to expected increases in personnel costs. Consequently, there is a recognized productivity crisis in the U.S. today that has made advances in office technology doubly attractive and important to organizations.

The intersection of technological availability and organizational need, then, provides a strong impetus for the introduction of computer-based information systems into myriad user settings. Both private and public sector organizations have viewed adoption of advanced information technology as a means to improved efficiency and effectiveness for *knowledge workers*. In fact, it has been argued that the development

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7 American Productivity Center, 1982.  
9 Johnson and Riesing, 1980; Welsh, Hodge, and Wahlberg, 1981.  
10 Smalheiser, 1983.  
11 Congressional Budget Office, 1981.  
14 Bikson, 1981.  
16 Branscomb, 1979; Keating, 1980; Parker, 1978; and others.
of information as a resource in an economy that is largely knowledge-
and service-based rivals the optimization of energy resources as a
national challenge.\textsuperscript{17}  

Because of the historic connection between workplace innovation and
productivity,\textsuperscript{18} it is instructive to review the experiences of early
organizational adopters of information technology. A number of careful
empirical studies have substantiated the mounting anecdotal evidence
that expected direct benefits are not readily realized.\textsuperscript{19} For example, a
survey of 2000 organizations that use computer-based information systems
found that about 40 percent failed to satisfy user objectives.\textsuperscript{20} In 8
percent of the cases, technical problems were to blame. However, in the
remaining cases, users cited reasons other than functional incapability--
e.g., poor problem definition, faulty project development, a badly
designed interface. Most attempts at technological innovation yield, in
Bair's (1980) terms, "working non-solutions," or systems that are at
once technical successes and organizational failures.

Comparable findings are emerging from NSF-supported research at
Rand on multifunction interactive systems, on which the planned research
will build.\textsuperscript{21} This Rand study finds highly functional software
applications and widespread usage among white-collar workers across
occupational categories in the project's 55 participating offices.\textsuperscript{22}
However, desired productivity improvements (defined as increased outputs
per unit of labor cost) were not observed in over half the research
sites. Neither users nor their managers believed they were fully
exploiting the potential of information technology. We later discuss
the specific reasons for this disjunction between expectations and
actual effects.

\textsuperscript{17} Bikson, Gutek, and Mankin, 1981; Rice, 1980.
\textsuperscript{18} Cf. Tornatzky et al., 1983; U.S. House of Representatives, 1982.
\textsuperscript{19} See reviews in and Bikson, Gutek, and Mankin, 1981; Kling and
Scacchi, 1982.
\textsuperscript{20} Diebold, 1980.
\textsuperscript{21} Bikson, Gutek, and Mankin, 1984.
\textsuperscript{22} Bikson and Gutek, 1983a.
The study's major conclusion provides the foundation for the planned research: The nature of the implementation process strongly influences the nature of the outcomes.\textsuperscript{23} Moreover, the central thesis of the planned explorations is that organizations that are attempting to use innovative information-handling technology must conceive of its implementation differently than they have in the past. Instead of trying to automate specific functions, they should attempt to augment generic functions; that is, they should implement interactive environments that enhance the generic information-handling and communication activities of white-collar work. For purposes of this research agenda, an interactive information environment:

- Includes an interactive interface to a computer(s).
- Allows users to access specific applications or databases.
- Lets users exchange information in a system congruent with organizational structures, task demands, and human communications skills.
- Increases individual and organizational productivity by enhancing memory, reasoning power, and communication.

The fact that diverse previous studies of innovative technologies have produced highly congruent results supports our focus on the implementation process.\textsuperscript{24} From these studies we have drawn two conclusions that will guide the planned research. First, if white-collar work has not succeeded in realizing major improvements from access to advanced information technology, it is likely that the problems reside with the implementation processes. Second, past and current research can be used to develop an appropriate conceptual framework and valid set of guidelines for approaching and resolving these problems. With the technical barriers to successful

\textsuperscript{23} Johnson and Taylor's (1983) investigation of word processing in organizations yields similar findings.
\textsuperscript{24} Cf. reviews in Berman and McLaughlin, 1978a, 1975a, and 1975b; Bikson, Gutek, and Mankin, 1981; Tornstzky et al., 1983; Yin et al., 1978.
implementation largely eliminated, we have an opportunity to focus research knowledge on issues of innovation and organizational change in this area of national importance.

GOAL AND OBJECTIVES

The goal of the planned work is to develop and test research procedures for understanding and improving the implementation of innovative information technology in organizational contexts. We plan to explore mechanisms for carrying our current work on computer and communications systems directly into field settings—that is, into organizations that have implemented or plan to implement such technology. We believe that our approach will have demonstrable advantages for both the research process and those who sponsor and participate in it. Drawing on the lessons of previous innovation studies, we plan a research approach characterized by:

- Problem-focused real-time field investigation that moves from prototype development through adaptive implementation processes to sustained assessment of the interactive information environments that result.
- Collaboration among disciplines (behavioral and technical sciences), among sponsors (industries, research institutes, and government agencies), and among stakeholders (vendors and users of computer-based information systems).

Establishing this paradigm will contribute substantially to knowledge about implementation processes and about research and development methods for addressing them. Equally important, by creating a mechanism for directly transferring research knowledge to contexts of application, our planned activities will give organizations the capability to take full advantage of advanced information technology and adapt it to better serve their own missions.

Our specific research objectives are to:
1. Analyze industrial research and development issues related to interactive information environments, generating a preliminary set of hypotheses about the implementation process and suggesting strategies for testing them.

2. Develop a collaborative research procedure for conducting such investigations and for ensuring the scientific quality and usefulness of the results.

3. Directly involve, as sponsors and participants, the organizations most likely to use the results in the research process itself to enable its self-sufficient continuation.

4. Establish communication procedures among participants that will promote (a) interactive specification of research objectives and processes and (b) evaluation and dissemination of results.

Achievement of these objectives will yield an empirical and systematic approach to understanding and improving the implementation of innovative information technology in organizational settings. Concurrently, it will contribute a new paradigm for investigations that span the domain—as yet not well explored—between basic and applied research.

In Secs. II and III we discuss the conceptual framework and empirical foundation for addressing the first two objectives and provide a preliminary description of field research strategies for meeting them. However, we cannot determine the final substance of and procedures for conducting the research until we have achieved objectives three and four. Sections IV and V present an institutional approach to these last objectives, describing a multi-sponsor organization whose members are jointly and interactively responsible for developing research and dissemination activities; Sec. VI provides a description of previous related research.
II. INTERACTIVE INFORMATION ENVIRONMENTS: THE IMPLEMENTATION FOCUS

As we have explained, the central thesis of the planned research is that implementation of innovative office technology should be conceived as the provision of interactive environments to support and enhance generic communication and information-handling activities in organizations. By implementation, we mean "the translation of any tool or technique, process or method of doing, from knowledge to practice";¹ it encompasses the range of activities that take place between the decision to use new technology and its incorporation into ongoing organized work.²

On the basis of previous research literature, we believe an adequate conceptual framework for investigating implementation must include three major components: (1) the innovative technology, (2) the context into which it will be introduced, and (3) the process of embedding the technology in the context. We treat these three components below.

THE IMPLEMENTATION PROCESS

The implementation process involves social units at different levels of aggregation (e.g., individuals, groups, corporations) in a sequence of activities that move from symbolic (e.g., deciding) to behavioral (e.g., training) and from early trials to later incorporation of innovative technology.³ We first characterize our approach to understanding implementation as it has developed out of previous work.⁴ We then present the problem orientation of the planned research: what

¹ Tornatzky and Johnson, 1982.
³ E.g., Tornatzky et al., 1983.
⁴ Because discussions of findings from implementation research are readily available (e.g., Tornatzky et al., 1983), we do not review them here.
has gone wrong in standard attempts to transfer computer and communications technology to organizational settings, and how we can take advantage of findings from previous implementation studies to explore and improve that process.

**Planned Approach**

We have derived our approach to implementation from an extensive review of the relevant literature and from two studies frequently cited above: the NSF-supported field study of implementation in private sector organizations⁵ and Rand's internal pilot project. From these sources, we have developed an approach that assumes a mutual adaptation model of successful implementation that is sociotechnical in emphasis.

The *mutual adaptation* model of innovation processes assumes that organizations do not have or require a *blueprint* for innovation, and that reinvention is not necessarily bad.⁶ The alternative perspective---the *fidelity* approach---judges implementation by how much the final result corresponds to the original, planned, or intended result of the process.⁷ For this approach, the critical parameters of an innovation must be specifiable in advance.⁸ We assume that both technological systems and organizational contexts do---and should---change during the implementation process. As we define interactive information environments, they are expected to provide broad sets of capabilities susceptible to substantial variability in use. Moreover, a key feature is that users may modify such tools and the environment in which they are embedded to accomplish diverse tasks. Consequently, the mutual adaptation model seems the only feasible approach to implementation research. It follows that the success of attempts to implement interactive information environments should be judged primarily by the extent to which changes in the innovative system and the organizational context promote the objectives initially intended.

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⁵ Bikson and Gutek, 1983a; Bikson, Gutek, and Mankin, 1984.
⁶ Rice and Rogers, 1980.
⁸ Tornatzky et al., 1980.
Second, because of the interrelationship of the social and technical systems involved, our approach to implementation will be sociotechnical. As Talbert (1980) has argued, electronic support for office functions raises joint behavioral and technical issues that--like the terms of a simultaneous equation--cannot be separately resolved. This approach contrasts sharply with the common practice of first choosing advanced office equipment and then modifying the social system to fit the technology. Consistent with sociotechnical principles, we will interpret the mutual adaptation model to mean that, during implementation, social and technical components must be considered equally and adjusted concurrently to achieve organizational goals. We must underscore the fact that if the process of introducing innovative electronic systems is indeed taken as a sociotechnical design problem, successful implementation will result in a sociotechnical organization in the traditional sense; that is, white-collar work groups will become "directly dependent on their material means and resources for their output." Although this fact necessarily follows from the interdependence of the social and technological systems constituting the work setting, it is nonetheless a major change for knowledge work and a source of distress and resistance. Uncertainty about these and other organizational ramifications of Office Automation is holding back many companies. They have well-founded concerns that implementation of interactive information environments may result in significant and enduring organizational changes. Consequently, such concerns require explicit consideration in sociotechnical design.

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11 Trist, 1981.
12 Seybold, 1983.
The two perspectives—a mutual adaptation approach based on sociotechnical design principles—together provide a coherent and well-developed framework for the planned research on implementation processes. A third assumption, specific to advanced office technology, provides its problem focus: Current efforts to automate the office have failed to adapt available technology to the generic communication and information-handling tasks of white-collar work. Instead, those activities have been suboptimally modified to fit discrete computer-based tools. Because knowledge about how to create interactive information environments is lacking, technology currently in place supports highly specific functions of organizations but not the internal communication and information environment in which these functions are embedded.

**Implementation Problems**

We believe that barriers to full realization of the uses of electronic technology can be surmounted only by well-implemented interactive information environments. Although few research studies have directly addressed this issue, there are growing reports, based on experience and analysis, about the need for integrated electronic environments. For example, data to support this view emerged from our study of advanced information technology in over 50 white-collar work settings. Responses from employees at various occupational levels in diverse work groups showed a fairly high level of satisfaction with the performance of applications programs specific to their particular missions. However, we found very little evidence of satisfactory support for activities they performed in common. At least half of the respondents write original material, proof, edit, and rewrite it; handle messages; and maintain files. Further, fully 96 percent reported that verbal interaction was a component of their work, engaging an average 60 percent of their time; nevertheless, 80 percent of the respondents rarely or never used computer capabilities for these purposes.

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14 Tapscott, 1982.
We obtained similar data from baseline measures taken before the implementation of Rand's internal pilot project. To assess the use of communications capability unobtrusively, we sent an electronic mail survey to all computer account holders. From the 639 queried, we received 186 replies, a 29 percent response rate. The distribution of responses indicated that outside Rand's technical departments, computer resources were strikingly underused. For example, although 78 percent of nontechnical users logged onto the computer daily, only 27 percent made frequent use of messaging, despite the central role of internal communications at Rand (which we established by tracking inbox/outbox and telephone activity).

Similar reports have come from other observers of office technology. In a recent discussion of electronic mail,\textsuperscript{16} the vice president of the ACM used the phrase "electronic islands" to describe the phenomenon we observed at Rand. In describing the sorts of outcomes we observed in the broader implementation study, Amy Wohl, president of Advanced Office Concepts Corporation, explained that technical skills are dispersed rather than integrated, with all functions separately mechanized and incapable of working together.\textsuperscript{17} There is evidence that both user and vendor organizations are beginning to identify the problem in these ways.

Speaking for users, a Computer Decisions article urged a process-rather than product-oriented approach to strategic plans: organizations "must focus on how office systems will support the business, and not on specific tools."\textsuperscript{18} Industry Week (July 1982) summed up the problem by saying that users want a universal technology to accommodate the increasingly numerous and complex array of computer and telecommunication tools. A 1982 Harvard Business Review article concurred, emphasizing that the difficulty can only grow as more technologies become available.\textsuperscript{19} Therefore, it urged corporations to intensify their planning for information systems.

\textsuperscript{16} Abrahams, 1983.
\textsuperscript{17} Dooley, 1981.
\textsuperscript{18} Zisman, 1980; cf. Keen, 1982; Lochovsky, 1983.
\textsuperscript{19} McKenney and McFarlan, 1982.
For vendors, these issues present a new market challenge. As a
Forbes report points out, the term *office automation* itself is a
drawback in this market. More and more vendors have begun to use
*office integration* as the more accurate term to describe system-oriented
attempts to access information and enhance human communication.
Galbraith and Kazanjian (1983) interpret this shift as part of a long-
term strategic redirection of the office products industry from a base
of mechanically engineered, stand-alone products (such as typewriters,
copiers, and dictating equipment) to one built around electronic
components all linked in systems fashion. They argue that by most of
its structural characteristics, the re-formed office products industry
qualifies as an emerging industry. As such, its major functional
concern must be research and development in product/market evolution.
Thus, from both users' and vendors' perspectives, we have evidence of
the growing need to replace anecdotal evidence and unanalyzed practice
with systematic investigation of how best to support information work.

**Improving Implementation**

Accounts of implementation issues, reviewed above, converge on the
lack of fit between the innovative technology and the organizational
context in which it is to be embedded. Specifically, electronic office
tools do not support and enhance the generic communication and
information-handling activities of white-collar work subsystems.
Rather, while they may automate particular functions, they are not
readily aligned with organizational communication structures nor readily
adapted to the multiplicity of tasks and behaviors that constitute
knowledge work. If the need to understand and improve the
implementation process is clear, its resolution is much less apparent.
However, the implementation approach and related studies described above
afford a viable basis for designing a program of field research and
exploratory development in this problem area. Three general guidelines
for improving the implementation of interactive information environments
have been drawn from that background and productively applied in Rand's
internal pilot research:

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28 Smalheiser, 1983.
- 13 -

*Start with what exists.* According to Hackman (1981), a major lesson from sociotechnical research is that "we must deal with organizations as they are when we enter them." For purposes of the planned research, this implies building on existing organizational structures and established patterns of communication and information handling. In addition, it means recognizing and enhancing the role of well-developed human communication modes. As data from our current study of computer-based office systems show, white-collar workers are highly educated. They have strong linguistic and cognitive skills that should be supplemented rather than replaced. Finally, this lesson argues for using extant technology. The preceding discussion suggests that organizations do not need more new tools. Rather, they need to take better advantage of those already available.

*Produce a good fit between the social and technical components to create complementary capabilities.* At minimum, adaptive implementation processes must promote effective interaction between individuals and computers. This implies providing a single, consistent, flexible interface to information and communication services through which individuals can carry out their tasks. White-collar workers should expend considerably less effort on the media than on the functions the technology is intended to support. Further, the implementation process must result in a technical system that maps key features of the organizational structure and pattern of information flow. Individuals must be able to use electronic media to enhance organizational work practices already in place.

*Orient the sociotechnical system to the mission of the organization.* As we will see, generation, transformation, and

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22 Cf. Trist, 1981.
23 Taylor, 1983.
transmission of information constitute the basic mission of white-collar work groups. Whatever else it offers, the technical system must augment these generic activities. Here, generic means that the system's design should rely for its critical features on a basic information-communication model. Its elements include messages (defined as chunks of content, regardless of whether they are composed from text, voice, diagrams, and so on), senders (who compose and transmit the messages), and receivers (either another individual(s) or the same individual at another time). Rand's internal pilot project suggests that this model provides a useful way of conceiving knowledge work for system implementation purposes.

We believe the Rand pilot project illustrates how these guidelines can be used to create an interactive information environment within an extant work group. That project and the NSF-supported field study have provided many of the ingredients for the planned research, including working prototypes, training procedures, assessment methods, and considerable implementation experience. Sections III and IV suggest a procedure for continuing implementation process research in field settings, based on the approach described. First, however, we will define the technology to be implemented as well as the implementation context.

TECHNOLOGY

The technology underlying this research is the task diverse\textsuperscript{24} and loose-bundled\textsuperscript{25} innovation constituted by multifunction interactive computer and communications systems. By interactive, we mean their activity must be user-guided to some degree. By multifunction, we mean that they are capable of supporting or enhancing diverse white-collar tasks. Varied specific tools of this nature have been developed—e.g., text processing, electronic spreadsheets, calendar management, electronic mail, database management, voice store-and-forward, graphics

\textsuperscript{24} Yin et al., 1978.
\textsuperscript{25} Rice and Rogers, 1980.
packages. However, they may be grouped into two major categories: tools for manipulating and transporting information in space, such as communications networks; and tools for manipulating and transporting information in time, such as filing systems.\textsuperscript{26} Outside of the requirement that the information system be interactive and multifunction, the technology focus of the planned research is fairly broad and may include many or few tools from each category. In particular, our definition of the technical domain of interest is constrained neither by the office system's architecture or transmission media nor by the nature of what is transmitted.

It is generally assumed that intra-individual and inter-individual information handling are the two critical dimensions of advanced office technology.\textsuperscript{27} However, the terms in current use do not uniformly accord with our terminology. For example, the March 1983 \textit{Seybold Report on Office Systems} says (p. 1):

\begin{quote}
In summary, then, at the crux of office automation are two key elements: personal computing power used productively by office workers . . . and electronic communications linking office workers to each other and to ever-changing banks of information.
\end{quote}

While we concur with this account of key elements of office systems, we do not describe them in terms of \textit{office automation}. As we noted above, that phrase itself is a drawback to thinking about interactive, multifunction information systems. \textit{Office} automation is often taken to mean the use of computer and communications technology to support organizations' administrative procedures, whereas the innovation we envision would support other sorts of white-collar work as well. Further, \textit{automation} is frequently associated with mechanizing or routinizing information-related work, while we have stressed its enhancement. Finally, we prefer the phrase \textit{interactive information environments} because it clearly denotes a generic and integrated conception of electronic information systems--systems that give

\textsuperscript{26} Talbert, 1980.
\textsuperscript{27} E.g., Bair, 1981; Engelbart, 1975a; Olson and Lucas, 1982; Tapscott, 1982; Teger, 1983.
individuals and organizations a pervasive capability that can be deployed to serve an unlimited number of specific functions. As Kling and Scacchi (1982) argue, it is more appropriate to regard this technology as a web rather than as a discrete entity.

Given these definitions, we view computer and communications technology much as Engelbart (1978) has described them: broad new sets of tools that will bring significant change to many of the ways in which people and organizations work, augmenting their capabilities and increasing both the quantity and quality of their contributions. Our NSF-supported study yields well-developed variables and procedures for characterizing such systems, while Rand's internal pilot project affords an operating example of an interactive information environment supporting generic communication.

CONTEXT

The discussion of advanced information systems above includes several references to offices and organizations because technological innovations cannot properly be understood apart from the contexts in which they are embedded.\textsuperscript{28} Recent research literature systematically finds that characteristics of the user setting have a major influence on the nature and outcome of efforts to implement new information-handling tools.\textsuperscript{29} We characterize the embedding contexts for these tools as behavior settings\textsuperscript{10} for organized white-collar work.\textsuperscript{11} In turn, for purposes of this research, we classify work as white-collar if generation, transformation, or transmission of information are important activities within it. Such activities are central to most descriptions of office or knowledge work, independent of the level at which it occurs in an organizational hierarchy.\textsuperscript{12}

\textsuperscript{28} Tornatzky et al., 1983.
\textsuperscript{29} E.g., Keen, 1982; Kling and Scacchi, 1982; Taylor, 1983.
\textsuperscript{10} Barker, 1968.
\textsuperscript{11} Gutek, Bikson, and Mankin, 1984.
\textsuperscript{12} E.g., Drucker, 1969; Ellis and Nutt, 1980; Engelbart, 1982.
In our NSF-supported project, we limited the study of white-collar contexts to settings where information products or processes were the primary mission of the work group (e.g., corporate strategic planning offices, legal services groups, engineering design groups, or order entry departments). For future research, we will broaden the definition of white-collar contexts to include work groups where information-related processes or products significantly affect the conduct of work, even though they may not be the primary mission. For example, a department within a medical facility would be an appropriate context for study if its physicians, surgeons, nurses, and staff used an interactive computer system to build electronic files and to communicate with one another, even though health services delivery remained their primary aim. However, the proposed definition of white-collar work will still exclude contexts where computers are used to control manufacturing processes, to record point-of-sale billing, and so on.

The planned investigation of implementation processes, then, targets white-collar work as it occurs in units within organizations as the context of study. We will treat the broader organization as a secondary or macro context. A review of level-of-analysis issues suggests that, while the individual user is too narrow a focus, the organization as a whole is probably too wide. Consequently, we have chosen primary work systems or work groups as the context of analytic interest. Trist (1981, p. 24) defines primary work systems thus:

These are the systems that carry out the set of activities involved in an identifiable and bounded subsystem of a whole organization, such as a line department. . . . They may consist of a single face-to-face group or a number of such groups together with support and specialist personnel. . . . They have a recognized purpose, which unifies the people and the activities.

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13 Bikson and Gutek, 1983a.
14 Ibid.
This characterization accords with the definition of "work group" that we used to define the context of the NSF-supported implementation study: a unit of four or more persons, representing at least two different occupational levels, whose work is related by output or by workflow technology.\footnote{Cf. Dewar and Hage, 1978; Rousseau, 1983.} We found that the work groups participating in that study could be classified into four types, based on their activities as a unit. We believe this research has established that such units of analysis are appropriate for implementation process research and has generated useful variables and measures for their assessment. For the planned field investigations, the implementation context may be composed of one or more such groups, as long as they have a common mission and common boundaries on an organization chart. Further, we will not constrain the organizational settings, as we did in the other project, to private sector sites. The units of study may be subdivisions of manufacturing or service organizations in either the private or public sector.

Although we have selected primary work systems as the major research context, we do not mean to ignore either the individuals who make them up or the organizations that comprise them. On the contrary, researchers and organizations alike must pay careful attention to the relationships between the primary system and its sub- and super-strata during the implementation process. Our discussion here was intended to develop a research-based concept of the office as the immediate embedding context for technological innovation. At the same time, we have sought to underscore the nature of the office as a sociological system\footnote{Talbert, 1980.} involving people interconnected not only by technical devices but also by tasks, occupational roles, organizational structures, and missions.

Section III outlines characteristics of a research procedure capable of promoting the transfer of information technology to such contexts, guided by previous studies of the implementation process. As an NSF report (1973) on science, technology, and innovation concludes, "the benefits of technology confluence should not be left to chance."
III. COLLABORATIVE FIELD INVESTIGATION: THE RESEARCH PROCEDURE

To explore strategies for transferring the benefits of information and communication technology confluence to organizational settings, we suggest establishing a program of implementation process research. Below we describe major outlines of a research paradigm that could be productively applied to this substantive area. Distinctive features of the suggested research approach include characteristics of both the method and the investigators who carry it out. For convenience, we discuss them separately here, although they are construed as highly integrated.

METHOD

Problem-focused real-time field investigation with implementation processes is the method of choice. In contrast to basic theory-oriented research, problem-oriented research addresses a cluster of issues around a core technology.¹ In Sec. II we defined the core technology, its embedding context, and the surrounding implementation issues that generate the problem focus for the planned research. Problem-oriented research to better understand the factors necessary for effective implementation of technology in the workplace was recommended in a report from the House Subcommittee on Science, Research and Technology.² Endorsing such an orientation for the study of interactive information environments, Engelbart (1978) argued that remaining technical research issues are no longer as numerous and challenging as those involved in learning how to harness the services that technology offers toward human ends. Similar calls for problem-focused research in this domain have come from Olson and Lucas (1982), who emphasize its urgency, and Keen (1982), who initiated the journal, Office: Technology and People to disseminate its findings.

¹ Tornatzky et al., 1982.
Next, field investigation of hypotheses selected for their implementation problem relevance is planned, in contrast to laboratory investigation of hypotheses chosen for their relevance to basic theory development. We will not review here the extensive literature on laboratory and field research methods. Instead, we will indicate why interactive information environments are best studied with naturalistic methods.

- We concur with Yin\(^4\) that field research methods are requisite whenever the boundaries between the studied phenomenon and its context are not sharp, so that not all the parameters of potential interest can be specified in advance and apart from the settings in which they occur—as required for laboratory research.\(^5\) The preceding discussion of electronic technology and its organizational context makes it evident that the implementation of interactive information environments falls within this category. We suspect that most sociotechnical systems research should be similarly described.

- As Deconchy (1981) contends, field methods are mandatory when research concentrates on processes that cannot be simulated, miniaturized, or otherwise artificially constructed without becoming distorted. In these cases, research must be conducted within relatively complete and intact settings. We believe that utilization of complex new tools for communication and information handling clearly has this characteristic. Were it possible to separate such systems from their contexts, independently manipulate key variables, and control all other factors in a laboratory design, the results would have little relevance to implementation processes in ongoing organizational settings.\(^6\)

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\(^3\) E.g., see Bernstein and Freeman, 1975; Campbell and Stanley, 1966; Cook and Campbell, 1979; Fairweather and Tornatzky, 1977; Fishman and Neigher, 1982; Guba and Lincoln, 1981; McGuire, 1973; and others.

\(^4\) See Yin, 1981, 1982; Yin et al., 1983.


\(^6\) Cf. Erdmann and Neal, 1971; Shulman et al., 1982.
In addition, field procedures are recommended if the outcomes are to make a major contribution to policy, planning, and practice as well as to general knowledge.\textsuperscript{7} The planned research is expected to disseminate findings from behavioral and technical science, in integrated and useful form, to public and private sector organizations. While "the state of the art in basic science may have only a limited relationship to normative practice in industry,"\textsuperscript{8} pilot investigations in real settings promise greater external validity and more rapid application of results.

Within a problem-focused field investigative paradigm, we envision a program of real-time pilot projects conducted in white-collar work subsystems that have agreed to introduce interactive information environments. The need for longitudinal study is, we believe, straightforward. In the first place, implementation is known to be a sequential process whose initial, interim, and final stages differ substantially; moreover, events early in the process have a significant bearing on subsequent ones.\textsuperscript{9} Second, the mutual adaptation model suggests that both the technical system introduced and the context in which it is embedded will change during the implementation process. On both grounds, it becomes important for field studies with this problem focus to be continued over an extended period.\textsuperscript{10}

Finally, we believe there are compelling reasons to employ pilot projects as the primary research vehicle. Here, pilot implementation projects are treated as quasi-experiments in formal organizations,\textsuperscript{11} where innovative technology is systematically introduced and used for normal work and observed results are the basis for decisions about

\textsuperscript{7} Cf. Clark, 1980; Fishman and Neigher, 1982.
\textsuperscript{8} Johnson and Tornatzky, 1981.
\textsuperscript{9} Cf. Bikson, Gutek, and Mankin, 1981; Tornatzky et al., 1983.
\textsuperscript{10} Cf. Olson and Lucas, 1982.
\textsuperscript{11} Campbell and Stanley, 1966; Cook and Campbell, 1979; Seashore, 1981, 1964.
incorporation and broader diffusion.\textsuperscript{12} The planned projects are experimental in the sense that they are trials;\textsuperscript{13} that is, they rely on a specifiable intervention in a bounded work subsystem, they identify and measure relevant variables, and they permit some testing of causal hypotheses. However, they are primarily quasi-experimental because neither sites nor individuals can be randomly assigned to major treatment conditions.

At the outset, the experimental or trial intervention must be, in Seashore's (1964) terms, syndromatic and massive. However, after installation of the technical system and its initial use, the extended time frame will permit study of successive planned modifications and their effects; within variations, true experimental designs may be embedded. The interactive information environments to be implemented are regarded as models whose critical features for research purposes are defined by the conceptual framework provided above together with the specific hypotheses or propositions to be tested (see examples below); they are taken as representative of the set of technical systems determined by such features. White-collar work systems will be chosen as experimental sites because they are representative of the settings to which the results should generalize or because they will afford a positive testbed; ideally, both conditions may be met.

We do not intend by this discussion to imply that pilot trials will be the only disciplined inquiry procedure employed.\textsuperscript{14} On the contrary, the planned research will probably also draw on theoretical analysis, technical development and prototyping, in vitro experiments, correlational studies, and ad hoc comparisons. Further, it is likely to borrow much from current approaches to case study,\textsuperscript{15} evaluation research,\textsuperscript{16} and action research.\textsuperscript{17} However, such methods will be used chiefly in the service of designing or interpreting field investigations. We stress the value of field projects as a powerful way of examining the effect of alternative technology implementation

\textsuperscript{12} Thorngren, 1983.
\textsuperscript{13} Cook and Campbell, 1979.
\textsuperscript{14} Cf. Cronbach and Suppes, 1969.
\textsuperscript{15} E.g., Yin, 1981, 1982; Yin et al., 1983.
\textsuperscript{16} E.g., Guba and Lincoln, 1981.
\textsuperscript{17} E.g., Clark, 1980.
decisions. We view them as particularly important because there has been very little field investigation of the implementation of computer and communications technology employing systematic intervention procedures. Case studies and post facto comparisons make up most of the research to date.\textsuperscript{18} While such investigations, including those we have conducted, are extremely useful for providing descriptive information and for hypothesis generation, they are distinctly less valuable for probing associations among variables of interest, for exploring causal relationships, and for arriving at generalizable conclusions. According to Thorngren,\textsuperscript{19} the knowledge they provide is "potentially invaluable to those user organizations who are presently considering whether and how best to introduce office automation as well as to suppliers trying to develop new services and systems for the office environment."

\textbf{INVESTIGATORS}

Having outlined the features of a method capable of yielding valuable knowledge about the implementation of interactive information environments, it is appropriate to ask why—in view of the importance of the problem domain—such approaches have not been more frequently attempted. The answer, we believe, lies in their scope, complexity, and associated resource requirements. For example, pilot trials of information and communications technology are ineffective unless they are widely implemented within and provide reasonably well-developed services for a user community.\textsuperscript{20} In addition, such efforts necessarily are long-term ones.\textsuperscript{21} Moreover, they cannot rely exclusively on either technical expertise or management and organizational development skills; rather, they require the coordination of both sorts of resources in a strategic implementation plan.\textsuperscript{22} Finally, useful pilot projects entail a

\textsuperscript{18} Tapscott, 1982.
\textsuperscript{19} Thorngren, 1983.
\textsuperscript{20} Engelbart, 1981; Eeland, 1983; Rogers and Picot, 1983.
\textsuperscript{21} Cf. Olson and Lucas, 1982.
sizable budget commitment that has to be considered, in Engelbart's terms, an exploratory investment.

This is not to argue that experimental pilot projects are too burdensome in comparison with expected benefits, but rather that most organizations are unlikely to be able to mount such efforts on their own. Further, the value of a single pilot trial is extremely limited in comparison with the knowledge to be gained from linked trials with shared goals and shared assessment methods. For these reasons we believe it is desirable to explore and develop collaborative procedures for the conduct of pilot investigations. The value of such an approach—uniting researchers, government agencies, and vendor and user organizations in a series of joint field projects—is suggested by the experience of Britain's Department of Industry. Currently supporting pilot trials designed collaboratively by vendors, users, and the Ministry for Information Technology in 21 field sites, the Department of Industry reports significant knowledge gains and diffusion effects.

Characteristics of the collaborative inquiry described below are based on research literature in technology transfer as well as discussions with the director of the U.K.'s experimental program and visits to three pilot sites.

First, field investigation of implementation processes as described here requires a multidisciplinary team of investigators. Such teams are distinguished by an integration of more than one kind of disciplinary expertise in the effort to solve a common problem, with group responsibility for the final product. Our approach is heavily influenced by the group problem-solving research tradition in which Rand (along with other matrix-structured R&D institutions) has played a precedent-setting role. It assumes that a multidisciplinary problem is one where, by definition, no single individual (or no within-discipline

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23 Engelbart, 1981.
24 U.K. Department of Industry, 1982; and personal communication, June 1983. Many more user organizations volunteered pilot sites than could be accommodated in the design.
25 See review in Bikson, 1980.
26 Following Cohen, 1982; Gillespie and Birnbaum, 1980; and others.
team) has the information, tools, methods, and ideas needed for its resolution; concomitantly, it emphasizes the instrumental value of communication in the research procedure. For the planned implementation studies, we give greatest importance to the union of information and behavioral sciences, with other disciplines to be involved as determined by the requirements of specific project designs.

Next, the scope and complexity of the suggested field investigations also require the participation of multiple sponsors pooling institutional resources. We will not review the developing body of literature on academic-industrial cooperation. Instead, we will clarify the appropriateness of collaborative sponsorship for this research agenda. As we see it, the implementation of interactive information environments constitutes a technological domain that lies between basic research and product- or firm-specific application. Generic research of this sort can yield significant benefits to many organizations, none of which could support such investigation individually. Moreover, collaboration between industries and research institutions is the most--if not the only--effective means of assuring the timely transfer of scientific knowledge in useful form to organizational settings. Although academic-industrial cooperation has sometimes been impaired by goal discrepancies, we do not expect those difficulties: Rand's incentive structure is built around the conduct of research that is at once policy relevant and scientifically rigorous. Government agencies such as the National Science Foundation are likewise

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28 Cf. Keen, 1982; Zisman, 1980. An instructive review of the varied disciplines that have made major contributions to innovation process research is available in Tornatzky et al., 1983.
29 See Eveland et al., 1982; National Science Board, 1982; Tornatzky et al., 1982.
32 E.g., Bernstein and Freeman, 1975.
regarded as appropriate sponsors to the extent that their mission involves improved understanding of implementation processes and the development of alternative research procedures for their enhancement.\footnote{\textsuperscript{33} Cf. U.S. House of Representatives, 1982.}

Finally, the investigation of interactive information environments should include the two chief stakeholders--vendor and user organizations--as direct participants in the research program. We see vendor-user interaction in the design of pilot projects as critical. On the one hand, research literature consistently reports the importance of user involvement in successful implementation processes;\footnote{\textsuperscript{34} E.g., Bikson, Gutek, and Mankin, 1981; Johnson et al., 1983; Tornatzky et al., 1983.} only they know the nature of the activities, the interactions, and the settings that the technology is supposed to support. On the other hand, users often do not know what electronic tools are (or will become) available, and lack the technical ability to adapt them to their work.\footnote{\textsuperscript{35} Bair, 1980.} For this reason, vendor participation is sought. Vendor product development, in turn, will benefit from increased understanding of the contexts of use. In consequence, we expect innovative activity to be stimulated within both sorts of participants: Vendors should be in an improved position to design new tools and services, and users will acquire the capability for their innovative deployment. We expect both new tools and new uses of extant tools to emerge from the collaborative process.

The resulting collaboration between vendor and user organizations in field research extends the bridge model of Goldhor and Lund (1983), where new technology is seen as transferred from an academic source to an industrial target by means of a transfer agent.\footnote{\textsuperscript{36} Cf. link agents, reviewed in Bikson, 1980.} The model described here assumes that an array of computer and communications technologies capable of enhancing white-collar work has already reached commercial development. Link agents representing both technical and behavioral science are needed to transfer the technology from industrial sources to industrial targets by means of an adaptive implementation process of the sort described above. We believe that a third-party link, knowledgeable
about advanced information tools and white-collar work systems but not identified with either stakeholder in the implementation process, will achieve the best results.\textsuperscript{17}

The desirability of creating linkages between sources and users of technology has already been acknowledged.\textsuperscript{18} However, its difficulty has also been remarked, particularly in relation to field trials. Documenting the Swedish Telecommunications Administration's attempts to survey office automation trials in Western Europe, Thorngren (1983) cites confidentiality as a major problem: "Some suppliers approached were unwilling to reveal information about planned trials or to risk publicizing any adverse results," and "end users may not want to publish information about their operations if it could be used to commercial advantage by their competitors." While we understand the seriousness of the confidentiality issue, we believe that carefully designed procedures will overcome the problem. First, we believe that the central role of the third-party link--the research agent--is critical to its solution. The collaborative research entity both supports the cost of field trials and bears the responsibility for project successes and failures; finding out what not to do may be as much a valuable learning experience as a positive result. The U.K. Department of Industry has found this approach highly successful; its field trials are noted as exceptions to the confidentiality problem in the Swedish Telecommunications Administration's report. Second, although research participants will know the identity of sites and of equipment involved in field trials, we would not expect to publish such information. Rand (see Sec. VI) has had extensive experience in field research where, as a matter of course, proprietary and sensitive data are collected and examined; in subsequent reports, private data are well protected while valuable public inferences are extracted. In contrast to the Swedish survey, Rand's field study of computerized procedures in office settings gave assurances of confidentiality and had little difficulty enlisting participants. For the planned field investigations, participants themselves will be directly involved in establishing privacy protection policies in research.

\textsuperscript{17} Bikson, 1980.
\textsuperscript{18} E.g., Tornatzky et al., 1983.
IV. PRELIMINARY PROCEDURES AND HYPOTHESES

A collaborative research effort embodying the methodological characteristics described above will be capable of providing an improved paradigm for systematic inquiry into implementation processes. In this section we offer illustrative procedures and a tentative set of hypotheses that could be brought to bear on the study of interactive information environments.

PROCEDURAL STEPS

Figure 1 depicts the procedural steps likely to be involved in the development and conduct of field investigations. The major steps are numbered, with relationships between them indicated by arrows. We should point out that this schema serves as a starting point for exploration and for iterative development of field research strategies in discussion with potential participants; it is not intended as a completed research design.

1. Each field research project begins with the identification of a set of conceptually integrated and high priority research propositions for investigation.¹ A multidisciplinary research team initially formulates an array of propositions that merit study, based on a cooperative analysis of industrial priorities in the implementation of interactive information environments. The actual set of research propositions to be investigated should be chosen in collaboration with organizational participants.

2. An agreed set of research propositions is operationalized in the form of field project designs by the research team (in cooperation with members of participant organizations' research, development, or human resource departments as appropriate).

¹ Following Olson and Lucas (1982), we use the term propositions here to include both causal hypotheses and other statements of relationships among variables that are subject to empirical corroboration.
Fig. 1 -- Overview of suggested procedures for pilot studies
Operationalization can be expected to entail technology modification and the building of prototypes, and may involve limited laboratory experimentation as well. These procedures give rise to a generic communication and information-handling system whose features are determined by the research propositions. In addition, operationalization involves determining an appropriate research design and assessment methods. As the background section indicates, Rand has experience in and available models for the technical production of interactive information environments and for their systematic assessment.

3. On the basis of the project design and the sample constraints it imposes, sites within sponsoring organizations are selected to take part (where participation is construed to include serving as an observed comparison group or as a pilot trial group). Two or more sites (white-collar work subsystems in the sense defined above) should be included in each field trial.

For sites involved in a pilot trial, the research team oversees equipment installation. In conjunction with site staff, it helps integrate the technology with existing information and communications media and will develop a maintenance plan.

The research team also oversees the development of training and documentation for users, facilitate the introduction of the technical system into regular work practices, and provide hands-on assistance during early use. Like the technical tasks, these tasks are initiated in collaboration with site staff; in both domains, responsibility subsequently shifts primarily to site staff. An extended period of trial use is anticipated.

2 We should note that Rand has had considerable experience in integrating new and extant systems and in producing documentation, training, and follow-up assistance for their use—see Sec. VI.
4. Systematic data collection efforts are undertaken by the research team, probably beginning before system installation (depending on the research design) and, in any event, concurrently with the period of trial use. We envision the use of multiple measurement methods including observation, interviews, surveys, standardized behavioral tasks, and archival indicators of work group performance; wherever feasible, instrumentation should be incorporated into the pilot technology.\(^3\)

The resulting database can then be subjected to formal quantitative analysis at preestablished intervals during the experimental period and at its termination, as required by research designs. Results can be supplemented with a wealth of qualitative information.

5. Interpreted results and supporting data are examined in relation to the initial set of research propositions, to develop a body of scientifically and practically valuable conclusions. In particular, it is of interest to determine which propositions should be construed as confirmed by patterns of findings replicated across sites; which should, by similar means, be rejected; and which remain dubious and merit reinvestigation by modifications of the research design in subsequent trials. Equally important, major implications of the findings should be developed and new research propositions worthy of study should be generated.

The weighing and evaluating of findings and their consequences is an interactive process that should draw heavily on the varied knowledge and collective experience of all the participants in the research. Of particular value for this effort is feedback from users in the pilot sites; as Guba and

\(^3\) Instruments to be used in future research will rely initially on those already developed and tried in organizational settings (see Bikson, Gutek, and Mankin, 1984).
Lincoln (1982) note, "naturalistic approaches take full advantage of the not inconsiderable power of the human-as-instrument."

Outcomes of these interactions can be disseminated in scientific journals and through other media more accessible to groups who may be interested in applying them (including vendor and user organizations not directly involved in the research, and government agencies interested in technological innovation and related issues). Of greater value in the dissemination process, we believe, is the interaction between researchers and industrial participants; we include here informal communications and project-specific exchanges as well as seminars and formal meetings. The timeliness, bi-directionality, and hands-on quality of the collaborative inquiry process are strong predictors of knowledge utilization.4

RESEARCH PROPOSITIONS

The general form of the research program described above has much in common with the procedures employed by NSF-supported University-Industry collaborative research centers5 and with Rand’s multi-sponsor process industries research agenda. It is, however, unique in its reliance on field investigation of implementation processes and the special relevance of vendor, user, and governmental collaboration with research institutions for this purpose. Moreover, the substantive focus of the research--interactive information environments--provides an excellent base for investigating hypotheses that reflect major assumptions in the sociotechnical mutual-adaptation model of implementation. While such hypotheses are generated from a consistent background of theoretical and empirical research on technological innovation, they are often at variance with current beliefs and normative practice about the introduction of advanced

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4 Bikson, 1980.
5 Tornatzky et al., 1982.
electronic systems into organizations. Consequently, the results may make important contributions both to implementation research literature and to the technological augmentation of white-collar work. Equally important, they are expected to be of immediate use to both vendor and user industries and to stimulate innovation in both types of organizations.

Presented below are ten initial research propositions recommended for study on these grounds. They presuppose an interactive system that supports generic communication and information-handling in the sense defined above but are indifferent to the kinds of contents about which these capabilities are deployed. Positive outcomes are interpretable in terms of level of system use, improved task performance, and accomplishment of work group objectives. These propositions are offered as sample questions whose resolution would have a major influence on the implementation process; actual propositions to be investigated are decided on the basis of participants' priorities.

1. The greater power users have to govern their interactions with an information system, the better the outcomes.

2. User-system interactions are best carried out in a flexible generative medium that takes advantage of linguistic and cognitive skills (instead of, for example, fixed menus).

3. It is better to teach users a model of the information system (formal operations) than to supply them with rote procedures (concrete operations).

4. Interactive information environments should be designed primarily to be used and only secondarily to be learned.

5. The primary impediment to successful white-collar use of computer and communications technology is fear of the technical system itself.

6. In the implementation of interactive information environments, similarities among users (based on common communicative behaviors and information-related tasks) are more important than their differences (e.g., based on organizational status).
7. The more important a task is to an organization's mission (e.g., managerial decisionmaking), the greater the value to be derived from its technological enhancement.

8. Because tasks are often allocated to teams (e.g., managers and secretaries, professionals and research assistants), it is as important to design information systems to support organized subgroups as to support individuals.

9. Provided with a generic and flexible information and communication system, organizations will further adapt (or reinvent) it to serve their own specific missions.

10. Enhancing memory, reasoning power, and communication capability among knowledge workers by means of an interactive information environment will significantly influence product quality in an organization.

Each of these research propositions is of interest for understanding implementation processes in general and for improving implementation of computer and communications technology in particular. They should be construed not as exhaustive but as representative of the kinds of questions to which collaborative field research might be productively addressed. Further, because they come from a common conceptual framework emphasizing interactive information environments in white-collar work subsystems, multiple issues can be readily integrated within field pilot procedures such as those outlined above. Finally, such a program of research will yield varied kinds of results (see Fig. 1), including design criteria for adapted computer/communications systems; developed prototypes; a methodology for implementation, training, and outcome assessment; findings about relationships among interactive information environments, individuals, and organizations; and implications for strategic planning in industry.
V. ORGANIZATIONAL STRUCTURE

The collaborative design of a research agenda and the creation of an organization for carrying it out are interdependent tasks. Conceptually, however, the institutional base is regarded as the vehicle through which innovative field research procedures of the sort we have described can be explored and tried.

Attaining the goals to which these exploratory efforts are directed requires the creation of institutional arrangements that will provide a continuing base for implementation process research. Decisions about how to structure such an organization will be guided by requirements implicit in the substantive focus and collaborative procedures of the planned research, and by reports from existing industry-university collaborative research centers.\(^1\) We will give special attention to the experiences of cooperative undertakings that have involved both supplier and user industries as research sponsors.

As the organizational base for the program of research, we plan to establish within The Rand Corporation an institute for the study of interactive information environments. Figure 2 presents a tentative organization chart for the institute, whose actual structure will be determined in consultation with potential participants during the exploratory process.

In this provisional organization chart, the planned research institute is located in Rand's Domestic Research Division. It will become a separate program within Rand's Private Sector Sponsors Program under the direction of the Vice President for Domestic Research, to whom the institute director will report (see institutional capabilities, below). Rand is an independent, nonprofit corporation that has always chosen not to do proprietary work for the private sector, although its undertakings are by nature problem-focused and policy-relevant. Its reputation for objective research is respected by industry, government, and academic institutions. Further, because it now serves as a base for two private-sector multi-client research programs, no new internal

\(^1\) Eveland et al., 1982; Tornatzky et al., 1982.
Fig. 2 -- Interactive information environments: A research institute tentative organization chart
divisional arrangements for management and fiscal administration are needed. Consequently, Rand seems well-suited to house an institute of the sort we have described. Formal aims of the institute, subject to agreement by its advisory body, are to:

- Demonstrate the generic role of interactive information environments for enhancing white-collar work.
- Transfer research knowledge from computer and behavioral sciences, in integrated and usable form, to organizational settings.
- Improve implementation capability and stimulate related technological innovation in vendor and user industries.

The director of the institute would assume overall leadership responsibility, assuring the overall superiority of the institute's research performance; overseeing the liaison with sponsoring members; and representing the institute within Rand, with responsibility for major fiscal and operational decisions.

The director would be assisted in the guidance of the institute by a Research Advisory Board. The board's major responsibility would be to provide guidance and counsel on the determination of research directions and priorities for the institute. In addition, the board would take part in project monitoring and in decisions about the dissemination of research products. Finally, it would participate in the development of institute governance and policies. The board would be composed of an executive-level representative from each major sponsoring organization; Rand's Vice President, Domestic Research Division; and ad hoc external members as appropriate.

Responsibility for maintaining the scientific quality of the institute's activities would be shared by the director with two senior research scientists, one from Rand's Information Sciences Department and one from its Behavioral Sciences Department. They should jointly serve as principal investigators for the research program, charged with the design, development, and conduct of the institute's projects (including major decisions about adaptation of information technology, its
introduction into work contexts, and data collection and analysis). Depending on the requirements of particular projects, they would draw on other members of Rand's scientific staff. Because of Rand's interdisciplinary orientation, there is a pool of experienced researchers with diverse training who know how to work as a team. In addition to the Information Science and Behavioral Science departments, for example, we would expect to involve staff from Engineering and Applied Sciences, Computer Services, Economics, and Systems Science in multidisciplinary research tasks.

Besides the members of Rand's research staff, the institute would encourage the participation of university faculty members in projects related to their special research interests. Rand has close ties to this community, with faculty members frequently consulting to Rand and Rand staff teaching university courses. We have already received expressions of interest in the planned institute from faculty at UCLA, USC, and UC-Irvine. The broken-line boundary around this potential group of participants in Fig. 2 indicates uncertainty about the most appropriate institutional arrangements for their inclusion. During the initial period, we will explore effective forms for their affiliation with the research program.

Research teams composed of Rand staff (and potentially university affiliates) will conduct pilot experiments in field settings under the direction of the principal investigators. The actual number of field projects under way at any given time depends on input from the Research Advisory Board, with pilot sites to be selected from sponsoring organizations. Within the pilot sites, experimental projects are to be carried out in close collaboration with site staff, who will be involved in all operational phases of the research. Their full cooperation is important because of the demonstrated significance of user involvement for the success of implementation processes and because, at the end of the experimental period, they will assume primary responsibility for the implemented sociotechnical system. Because of the importance of good working relationships with organizational sites, research teams will include Rand staff members with extensive experience in social experiments.
While conducting an innovative and productive program of research is the major goal of the institute, it aims to do so through a collaborative sponsorship mechanism. Interaction among sponsoring organizations and between them and the institute is essential for research development, research support, and research dissemination. These linkages will be the responsibility of a communications liaison, guided by the institute director. During the exploratory period, the primary role of the communications liaison will be to represent the institute's program of research to potential sponsors and assist in gaining their support. Solicitation of new member organizations will continue after the formal establishment of the institute, but it will be a lower priority than assuring continued contact with participating organizations. Implementation is inherently a continuous and noncomplete process. In the core technology area to which this research agenda is addressed, moreover, two factors will make sustained participation highly beneficial to both vendor and user industries. First, new information-handling devices and communications media will continue to emerge rapidly. Second, their integration into work contexts is expected to stimulate further innovation and consequent implementation activity.²

Several avenues for interaction among institute participants are planned, for which the communications liaison will have direct responsibility. These include formal conferences, informal meetings and site visits, prepublication circulation of research findings, and the like. Most important, we will explore and develop an electronic message network to provide communication links between the institute and member organizations. The message network will also serve as a first demonstration of the efficacy of generic information-handling systems and of the institute's implementation capability.

MEMBERSHIP

From an organizational perspective, industrial members are linked to the institute through the communications liaison. A major task in the exploratory period will be to determine the most appropriate

² See Goldhor and Lund, 1983.
membership structure and pricing policy. In Fig. 2, two kinds of memberships are envisioned, associated with different levels of participation, cost, and benefit. The broken boundary around associate members indicates that this category is tentative and dependent on decisions to be made in consultation with sponsoring members during organizational meetings. In addition, the possibility of other membership types is left open. We believe a tiered membership structure is highly desirable, primarily because of the broader potential for technology transfer, knowledge utilization, and stimulation of organizational innovation. Furthermore, being able to assess diffusion effects as a function of type of involvement and interaction with the research process would itself yield valuable information. Finally, we believe that benefits accruing to different membership levels could be made sufficiently distinct that sponsoring organizations would not be reluctant to admit lower-fee, less-advantaged members (nor would they want to give up the benefits of sponsorship). However, establishment of an institute depends only on the securing of sponsoring members and does not require the existence of other membership levels. With these caveats, we will describe the tentative membership structure depicted in Fig. 2, giving greatest attention to sponsor organizations.

- **Sponsoring members**, expected to make initial three-year commitments to participate, are actively influential in forming the institute, determining the research agenda, and advising on policies and procedures. Each has one seat on the Research Advisory Board, to be filled by a senior executive in the organization; senior executives will additionally attend one conference a year, at the Chief Executive Officer level, hosted by the institute. Further, each sponsor may send additional representatives to semi-annual sponsors' meetings, where research projects will be reviewed and their implications discussed. Of perhaps greater importance, sponsoring organizations will have the opportunity for informal interaction with research teams in relation to particular projects of interest as well as access to technical assistance
in applying the results; and only sponsoring organizations may host pilot projects. Finally, we plan to provide sponsors with an electronic mailbox and the capability to communicate with the institute and with other members; and they will have advantageous access to licenses derived from any patents or copyrights obtained by the institute as a result of its research.

- *Associate organizations*, if accepted as a membership category for the institute, might be enrolled on an annual basis for one-year (renewable) memberships. Associate members should be permitted to send a senior executive to the CEO conference and to send representatives to semiannual research meetings as well. They might additionally be entitled to an electronic mailbox and communications with the institute on a fee-for-service basis and should have early access to institute research publications.

- *Other*: The sponsors and the Research Advisory Board may elect to form a third membership category—for example, a membership level with privileges approximating the subscription to a newsletter (electronic or otherwise). The fundamental purpose of such memberships would be to gain access to information of value provided by the institute.

Funds from member organizations will take the form of basic research grants to The Rand Corporation. Rand qualifies as a tax-exempt organization under Section 501(c)(3) and related sections of the Internal Revenue Code. Consequently, grants may be able to qualify for a credit under the Basic Research provisions of the Economic Recovery Tax Act of 1981.

**POLICIES AND PROCEDURES**

Other institute policies and procedures, such as membership and dues arrangements, are to be explored in organizational meetings with sponsors and will be decided in consultation with the Research Advisory Board. For the field research agenda contemplated, the most critical issues are expected to be equipment policies; patent, copyright and
license agreements; and the treatment of proprietary versus public information. As a basis for discussion with potential members, we tentatively suggest the following procedures.

Equipment acquisition is likely to be important as an issue in the development and conduct of pilot projects. We believe the sharing of costs between the institute and a pilot-site organization, as well as the disposition of equipment used in an experimental trial, will be governed by the principle that research risks should be borne by the institute and not by the pilot site. However, the normal operational costs of the site, exclusive of any incidental benefits that might accrue to the organization by virtue of interaction with institute staff or as a byproduct of the experiment, should be borne by that organization and not by the institute. The actual allocation of costs and the disposition of the equipment at the termination of the trial period can be decided case by case in accordance with this principle. In each case, the institute and the pilot sites will negotiate an agreement acceptable to all participants. Equipment needs for technical adaptation, prototype development, or in vitro experiments are expected to be less extensive. We would expect to meet them, insofar as possible, with loans or donations from vendor organizations.

In attempting to improve the implementation of interactive information environments, institute activities might result in the design and production of new hardware devices or software applications. Any patents or copyrights arising from work conceived and carried out by the institute in the course of its research should be retained by the institute. However, all institute sponsors will be entitled to a non-exclusive and advantageous license agreement. Other fee-bearing licenses can be made available to nonsponsor organizations in a manner to be determined during the exploratory period. Monies derived from fee-bearing licenses will become part of the institute's budget, to be used only for research support.

Problems of proprietary and public data in field investigations have already been raised as an issue for multi-client research (see Sec. III). Since its founding, Rand has enjoyed a unique position at the interface of government and the private sector. Assembling databases
that contain proprietary and sensitive information has been standard practice for over three decades. During that time, Rand has gained a reputation for objective research and a demonstrated ability to extract valuable public knowledge from a collection of privileged data while safeguarding proprietary information. Access to proprietary data in the course of planned institute research will be safeguarded following established Rand procedures; no such data will be disclosed without written authorization from the source. However, Rand will disseminate results of institute research in scientific journals and other public media. Sponsoring organizations will have an opportunity to review drafts of research products before release. This procedure reflects Rand's practice of seeking comments from clients and selected reviewers before publishing research reports. The review period may also be used for industrial sponsors and Rand project staff to discuss the research results. The Research Advisory Board will help to devise and oversee review procedures. However Rand will reserve the right to release all findings it deems correct, subject to nondisclosure agreements.

Evaluation of the institute's activities and their outcomes will be modeled after procedures employed in Industry-University Cooperative Research Centers funded by NSF, to take advantage of extant assessment methods and to permit comparison of resulting data.\(^3\) Specifically, evaluation efforts will have four targets: (1) institute history, as represented in a collection of program documents and interviews with program staff; (2) organizational structure and profile, derived from questionnaires to administrators and senior researchers; (3) network of interactions and information transactions, based on questionnaires to both institute and sponsoring organization staff, and supplemented by the logging of activity patterns on the electronic messaging system; and (4) organizational effectiveness, represented chiefly by the institute's attainment of primary survival objectives and additionally by the nature of the research products it develops.

**BENEFITS TO PARTICIPANTS**

Across membership levels we will encourage participation by diverse industrial sponsors, including providers of computer and communications

\(^3\) Tornatzky et al., 1982.
hardware, software, and services; corporations and government agencies that have acquired or plan to introduce advanced office technology; and other organizations interested in implementation processes or technology transfer. As we see it, incentives for participation are various and compatible. Industrial members will benefit from a timely and comprehensive understanding of computer and communications systems in white-collar work settings, whether as user organizations seeking an informed basis for technology deployment and strategic planning or as vendor firms interested in improved product design and marketing. In particular, vendors will derive from extensive implementation experiments a better understanding of user contexts, user reactions, and the kind of implementation support required to introduce new technology into a work setting. According to an October 1982 *Word Processing* report, consumers are "getting tougher," demanding that corporate needs be met instead of allowing vendors to rule the market. Further, involvement in *generic* research not coupled immediately to a market product has been shown to engender a variety of products and services. In addition to the stimulation of industrial innovation, the U.K. Ministry of Information finds the most important benefit yielded by its pilot trial investigations is an improved ability to move rapidly from identification of market need through research and product development to commercial distribution.

User organizations also stand to benefit from involvement in research on office technology because they face an increasingly information-dense business world and burgeoning internal operations costs. Systematic field investigation will provide a sound basis for justification of productivity improvement and cost reduction investments related to advanced information technology. Further, they should derive much improved estimates of expected effects of these systems on organizational structures and on human resource requirements. In addition, participation in the research program will generate better

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4 A survey of Fortune 500 firms found that 30 percent would not give return business to vendors of their present equipment, chiefly because of inadequate training and other implementation support.
approaches to change management, together with new methodologies and measuring tools for examining organizational outcomes. These capabilities will be of continued value in light of the ongoing change that will undoubtedly accompany the emergence of new computer-based information tools throughout this decade.

Finally, the benefits to Rand from the establishment of the planned institute are considerable. Through iterative field investigations, we will be able to build and refine a potentially powerful new methodology—a paradigm for carrying out multidisciplinary real-time research that moves from prototype development through implementation processes to sustained assessment of information technology in contexts of application. Equally important, the institute will serve as a repository and disseminator of knowledge about the impact of interactive information environments on individuals and organizations. This will improve Rand’s ability to provide state-of-the-art information and policy guidance for public and private sector decisionmakers regarding a profoundly important area of science and technology.

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8 Bikson and Gutek, 1983b.
VI. BACKGROUND FOR THE RESEARCH AGENDA

Because of its established reputation for multidisciplinary policy-relevant research in general and a background of work in areas closely related to the focus of the planned studies, we believe The Rand Corporation is well suited to house the institute. This section summarizes research activities that provide a special foundation for the institute's investigations.

Two ongoing Rand projects concern the implementation of advanced information technology in white-collar work subsystems: an internal office automation pilot project, and a broader field study of computer systems in diverse corporate settings. The office automation pilot project began in February 1983 and is still under way. Its goal is to improve the efficiency and effectiveness of communication and information handling activities in the corporation using an experimentally developed interactive computer system and field trials initiated within Rand's executive management. Specific objectives of the project include:

1. Assessment of relevant Rand communication and information handling procedures and identification of major avenues for improvement.

2. Implementation of a system that mirrors Rand's organizational structure and enhances current message-exchange methods.

3. Determination of the impacts of the system on office performance.

Primary participants in the study are Rand's vice-presidents, their administrative assistants, and their secretaries—although diffusion effects from innovation at the CEO level have resulted in a much broader user community. To date, the first two objectives have been accomplished; impact assessment is scheduled for early 1984. However, we believe that the project already supports some of these major interests for the planned work. First, the project demonstrates the
appropriateness of communication activity as the starting point for developing an interactive information environment. Second, confident person-to-person messaging and data exchange can be effected without special access knowledge about login names, host computers, and the like. Next, it became evident that the technology has to support user teams (because that is how communications are managed) and to align itself with organizational structures (because that is how information flows in real work settings). Finally, system implementation indeed poses both technical and behavioral problems that must be jointly addressed by a multidisciplinary team. By means of this pilot project, the Rand team has developed experience and insight into their resolution.

A second project, begun two years ago with NSF support, has investigated the implementation of advanced office systems in external settings. Its task was to identify the major factors affecting how information technology is incorporated into white-collar work and to learn how alternative choices in the implementation process affect individual and organizational outcomes. Over 500 employees representing 55 departments in 26 different private sector organizations participated in the project. Data collection procedures included an extensive employee survey and interviews with each work group head, plus descriptions of the computer systems in use and related budgeting and staffing patterns. A balanced subsample of about half the sites participated in a one-year follow-up assessment. Outcomes included level of system use, user satisfaction, and achievement of organizational objectives (such as reduced labor costs, increased productivity).

As we expected, characteristics of both the organizational context and the computer system significantly affected outcomes; however, implementation processes (such as an organization's approach to technological change) had the greatest effect. Although research conclusions from this study will help guide the institute's agenda, the study procedures themselves also provide valuable background. For example, we have first-hand familiarity with a variety of white-collar

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work groups whose information-handling activities we have probed in detail. These observations have lent strong support to the thesis that although highly specific office functions are being separately automated, the generic communication structure in which they are embedded is neglected. Further, site visits underscored the importance of user participation in the implementation process, with effective dialog between technical and substantive experts a condition of success. Finally, we believe we have a tested conceptual framework for addressing problems in the implementation of information technology in real-world settings and a well-developed set of inquiry tools with which to begin.

Besides primary research on the implementation of computer-based information systems in office contexts, Rand has an extensive background in other areas of research related to innovation and organizational change. For example, the precedent-setting studies of educational innovation carried out by Berman, McLaughlin, and their colleagues shaped the mutual-adaptation implementation perspective of both the current and the planned research.² That framework was refined and extended in a series of studies of technological innovation in local government settings by Yin and his colleagues;³ Yin's routinization construct helped to define the notion of incorporation of new technology employed in the current NSF study. As a National Research Fellow of The Gerontological Society for 1979, Bikson was charged with developing a model of research utilization and technology transfer drawn from this background and applied to the area of gerontology research; in that capacity she prepared an analytical literature review and set of recommendations that was formally adopted by the Administration on Aging.⁴ We have updated the review of literature on implementation of innovative technology on two subsequent occasions—in 1980 during the preparation of the proposal to study computerized procedures in office settings⁵ and again during the preparation of this document. Finally,

⁴ Bikson, 1980.
⁵ Ibid.
to gain wider knowledge of field investigation with information technology in office contexts, Bikson visited three of the U.K. Department of Industry pilot projects and interviewed their directors. In addition, we have contacted all the projects documented in the Swedish Telecommunications Administration's survey of European office automation pilot trials and have begun to receive sample materials and reports. These efforts, together with our own research, yield a broad base for designing the institute's program of study.

Previous work on interactive computer systems establishes Rand as a leading research institution in the technology area to which the planned program is addressed. In particular, Rand has had a long and productive history in the area of artificial intelligence and expert systems, leading to the development of both programming languages and applications based on them. Rand has invented and developed JOSS, the Rand editor, the Rand tablet, and Videographics; more recently it produced RITA, introducing the idea of an English-oriented syntax to rule-based programming. Work is currently under way on ROSIE, which combines RITA's English-like syntax and powerful pattern matching capabilities with innovative, state-of-the-art database and expert system language design. ROSIE is a powerful, expressive language for building expert systems that is easy to read and understand. Also under development is ROSS, a successor of JOSS, which uses an object-oriented approach to language design. ROSS is a language that makes simulations easier to build, maintain, and understand. "Time Warp," a fairly new capability, speeds up object-oriented simulations by concurrently executing them on a network of processors. This technique also allows users to run a simulation forward in time and then, event by event, undo that simulation's execution.

Of particular relevance for demonstrating Rand's capability not only to design and build advanced interactive systems but also to implement them for users who vary greatly in level of experience and type of work are its interactive maps and its message-handling
system. Building on the Rand tablet and Videographics background, Shapiro and Anderson created an interactive map display system that embodies many advantages of traditional maps along with important additional capabilities for aiding geographic planning and other sorts of problem-solving. Experimentation with those systems generated many useful guidelines for developers of computer-based map systems. The message handling system (MH) developed by Shapiro and others provides tools for users to compose, send, receive, store, retrieve, forward, and reply to electronic text. It served as the basis for the communication system introduced as a part of Rand's internal pilot project. Although MH has many of the features found in other message systems, it has unique properties that reflect the implementation guidelines discussed above: user adaptation of the information environment and system integration. For example, MH commands are generated from and update a private user environment that is stored as a file between program invocations. This private environment also contains information to custom-tailor MH to the individual user's preferences. Further, MH stores messages as separate files under UNIX (the operating system for many of Rand's computers). By using the tree-structured UNIX file system to organize them, MH makes all UNIX file-management facilities (renaming, copying, deleting, cataloging, and so on) applicable to messages. Thus, important capabilities needed in a message system are available in MH without the need for duplicating the facilities of the supporting operating system. It also allows users familiar with the basic system to use message-handling capabilities with minimal effort, and vice versa. Widespread adoption of MH in the UNIX community suggests that these design principles make for effective system use and lend confidence in the technological orientation of the planned institute.

Finally, in recent years Rand has demonstrated its capability to attract private sector clients and carry out multi-sponsor research agendas. Although historically the federal government has been our major research sponsor, much of Rand's work has also proved valuable to industry. Private companies have often provided Rand with the proprietary data necessary for its research. By pooling these data,
Rand has been able to develop methods and analyses that provide tangible benefits to both government and industrial participants. Prominent examples include tools for assessing the capital costs and performance of innovative process plants, and a variety of analytic techniques now employed in the aerospace industries: parametric cost estimation of systems and subsystems, methods to estimate development costs and schedules, pioneering work on the learning curve concept, and analyses of how to organize and manage the development process.

To expand research that addresses both public and private sector concerns, to ensure that the research results are transferred effectively to the private sector, and to promote interaction between Rand and industry staff, Rand established a Private Sector Sponsors Program. Program support is administered through a special research fund directed by Rand's president, and research and related activities are conducted under regular Rand procedures and organizational structures. Industrial sponsors qualify for a credit under the Basic Research provisions of the Economic Recovery Tax Act of 1981. There are two such programs currently in operation.

The Institute for Civil Justice (ICJ) has as its goal the development of empirical information on the effect of legal rules in terms of both their intended consequences and their collateral effects, desirable and undesirable. To understand how legal rules influence outcomes, the ICJ examines their effects on the productive and disputing behavior of various actors in the system and on social outcomes (including economic and social goods and services). Completing its third year of activity in spring 1983, the ICJ has a research staff equivalent to 21 full-time professionals drawn from economics, behavioral science, law, statistics, information science, cost analysis, and operations analysis. With more than 200 sponsors, it operates at a funding level of about $2.2 million annually.

In January 1983, a second private sector sponsors program was formally established with process industry clients. Its research agenda builds on Rand's previous investigations of alternative R&D investment strategies, commercialization potential of new technologies, and factors that affect project planning. Current efforts emphasize developing new approaches to project evaluation that encompass cost estimation,
scheduling, assessments of system reliability, and management of the planning environment. Staff involved in process industries research come from engineering and applied science, economics, behavioral science, cost and operations analysis, and law. With six sponsors, it has an annual operating budget of approximately $700,000.

Additional information about Rand research activities described in this section may be obtained by requesting referenced reports from Rand's Publications Department or by contacting the researchers directly. We believe this overview of relevant work is indicative of the rich and varied background on which future research on interactive information environments might build.
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