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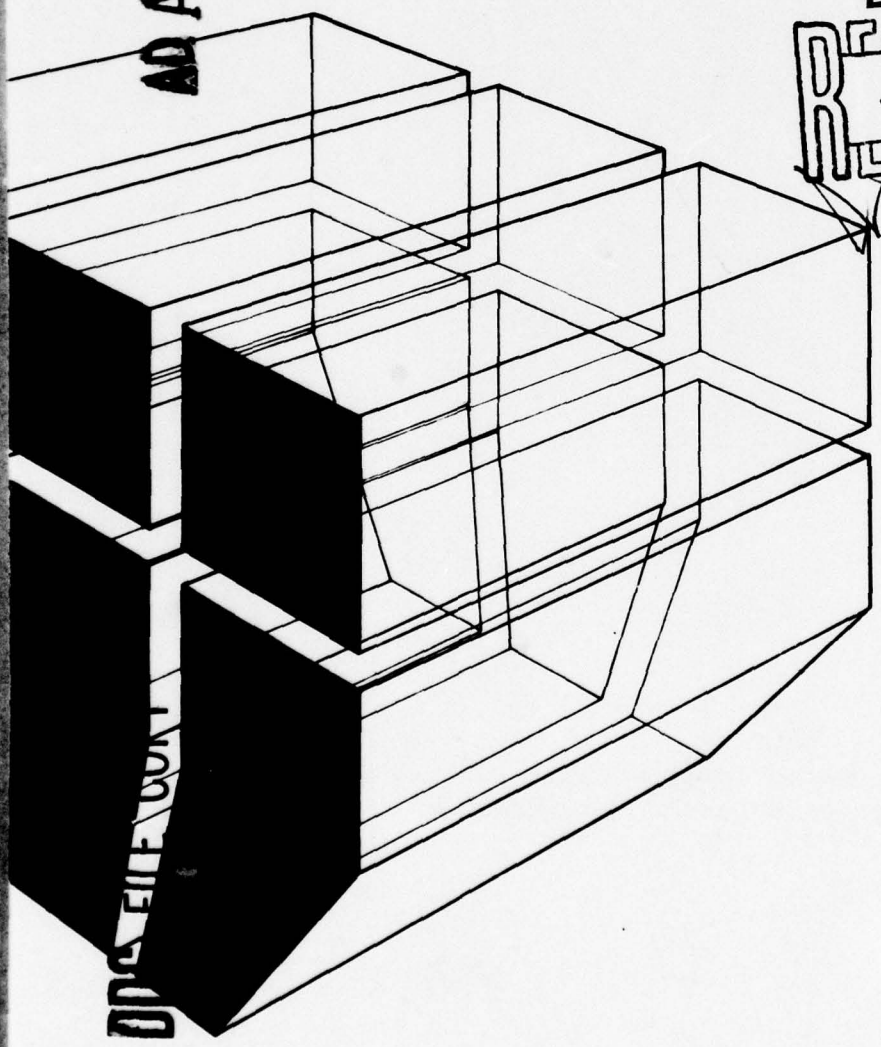
BLOCKS TO EFFECTIVE TECHNOLOGY TRANSFER IN CONSTRUCTION



by
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This report documents the findings of an investigation of the difficulties of implementing research results affecting management techniques in construction. Several civilian and military organizations dealing with construction were contacted and studied. The initial approach was to attempt actual implementation with "off the shelf" management tools, studying the problems of technology transfer as they occurred. The approach was changed to a "case study" in which the problems of implementation were observed.

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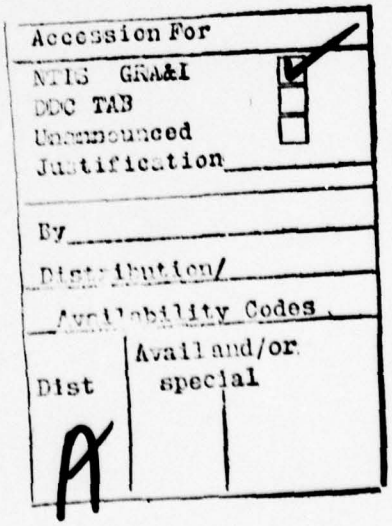
Results show that the technology transfer process is severely impeded by problems of a behavioral nature and hinges critically on the interaction of personalities along the transfer chain. This report documents the blocks to effective transfer, which include lack of effective communication, lack of an innovative environment, and the resistance of personnel to change. Suggested ways to reduce the effects of these blocks are offered.

FOREWORD

This investigation was performed for the U.S. Army Construction Engineering Research Laboratory (CERL) under the direction of Dr. L. R. Shaffer as a joint research effort with the U.S. Military Academy, through the Dean of the Academic Board Research Program.

This investigation was performed by Major T. C. Ryan, Assistant Professor, Department of Engineering, United States Military Academy, West Point, New York.

Colonel C. H. Schilling is Head of the Department of Engineering, and Brigadier General F. A. Smith, Jr., is the Dean of the Academic Board. Colonel J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.



CONTENTS

BLOCKS TO EFFECTIVE TECHNOLOGY TRANSFER IN CONSTRUCTION

1 INTRODUCTION

Background

In 1976 the construction industry emplaced approximately $144 billion in nonresidential construction, making it the largest industry to share in the Gross National Product. The construction industry is made up of tens of thousands of small businesses which are intensely competitive, but traditional in their approach.

Construction is basically a "job shop" operation, since orders for buildings come from different sources and require different quantities and designs; in addition, the time allowed for completion may vary according to negotiated contractual terms. Many different construction trades skills are used to build a facility, and few repetitive or standardized operations can be used because of each product's uniqueness.

In this environment, effective management is extremely challenging, since profit margins are fairly narrow and failure rates are high. One would anticipate that applying innovative techniques to the latest technology would be equated with success; yet, nothing could be further from the truth. Less than 1 percent of the industry's gross revenues is invested in applied research. Most companies will not invest in applied research because they cannot effectively protect the profit advantages gained by using these innovations from competitors.

Since little research is done by the industry at large, innovations must originate from other sources, such as governmental, educational, and private organizations. Literally millions of dollars are spent every year in the pursuit of making "a better mousetrap." An increasing share of this expenditure is devoted to improving the efficiency of management tools which are typically software- and applications-oriented, such as network analysis, automated estimation, cost control systems, resource allocation techniques, etc. Despite these improvements, however, construction productivity is stagnated, with costs continuing to rise and quality decreasing.

Technology transfer has been under close examination for the past few years, particularly by the Federal Government. Simply stated, technology transfer is a conscious effort to move innovations from discovery to application. Effective transfer becomes imperative as research costs

escalate. A continuing lack of communication between suppliers and users of technical information will result only in the widening of "the knowledge gap."[1]

The construction industry must employ every possible means of remaining competitive as projects become larger in scope (the Alaska pipeline, off-shore drilling platforms), technology becomes more complex, governmental regulation becomes more exacting, economic and cultural effects from energy and critical resource shortages become more acute, and inflation and societal standards become more demanding. Effectively closing the research loop between the researcher and the user may prove to be a way to hold costs down while increasing construction productivity and quality.

Objective

The objectives of this study were twofold: (1) to identify and define the problem of technology transfer as it impacts on construction, and (2) to determine methods of reducing the identified blocks to effective management of tool technology transfer.

Approach

The initial approach to this research was to have been the formation of an experimental unit of construction companies which would try to implement management tools that were already developed and well documented but had never been used. Representatives from these companies were to meet periodically, analyze each other's progress, compare problems, and discuss means of overcoming blocks to implementation. The author was to serve as observer, coordinator, and trouble shooter in this effort. Unfortunately, it was impossible to get enough companies to commit themselves to make this effort valuable as a research methodology.

Therefore, an interview and case study methodology was adopted which required less commitment from the organizations. This approach eliminated the necessity for periodic meetings. The author and representatives of several construction organizations (see Appendix A) selected a management tool that had been implemented within the past 5 years and traced the development of the tool from concept to full implementation. Next, the author interviewed both proponents and opponents of the implementation. The results of this process provided

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[1] R. G. Havelock and K. D. Benn, "An Exploratory Study of Knowledge Utilization," in G. Watson, Concepts of Social Change (NTL Institute for Applied Behavioral Science, 1967).

the data with which the technology transfer problem could be defined and gave insights into potential means of overcoming transfer blocks.

Scope

This study was not intended to investigate new product infusion, new construction technique implementation, or other hardware-oriented innovations. It only attempts to assess the technology transfer problem as it applies to the implementation of management techniques.

2 BLOCKS TO EFFECTIVE TECHNOLOGY TRANSFER

Introduction

Effective technology transfer is important because of its potential to improve construction operations, thereby indirectly increasing profits, quality of construction, and company reputation. Technology transfer occurs when (1) a concept is developed into a source of information, (2) a mechanism for the transfer is present, and (3) there is a user who needs the information. There are many pitfalls and hazards along the path to full technology transfer, particularly because human beings -- and therefore their associated behavioral characteristics -- are involved in each step.

Sources of information on research applicable to the construction industry are abundant. Although there is no central clearinghouse for research information, several organizations provide automated bibliographic retrieval on request and publish newsletters that are available on a subscription basis.

Although most construction organizations are well informed about new procedures, many lack knowledge about information sources. Trade journals and magazines are generally available to employees, and most organizations encourage professional participation at conferences and symposiums or in continuing education courses. These techniques are valuable as aids in the transfer process primarily through informal personal contacts and individual efforts, rather than through a formal program.

While it is true that effective transfer cannot take place if users are not made aware of innovations, there is no evidence that more information sources are required. It appears that the existing sources are simply not being used fully.

Information Producers

Once an innovation has been gleaned from a source, there must be a mechanism to implement it. A major block to effective transfer exists between the researcher or information producer and the implementor, mainly because of a lack of effective communication.

For example, each time a typical research paper was introduced to the members of a construction organization, it became apparent that the researcher and the practitioner were simply not on the same wavelength. Most research reports appear to be written for contemporary consumption, research sponsor consumption, academic reputation, or for other obscure reasons, but not for the user. In the construction industry, most employees are operators; that is, they like to get things done quickly.

They have little patience for mathematical derivations, sophisticated scientific notation, laboratory procedures, data reduction and correlation, etc. They basically want to read about how an idea can be implemented and how it can save them money. Typical journal articles and conventional research reports were met with such comments as "...absolutely the biggest waste of time...," "I couldn't make anything out of this," "...too fancy in wording," "...could not understand what the paper was supposed to prove," "the material is entirely too formal to encourage me to decipher the information in an attempt to decide if it applies to my operation." As a result, even if a good idea gets to the user, it may be rejected because the researcher has failed to communicate it effectively.

Researchers are typically no-nonsense, hardworking individuals who want their ideas to be *used*. However, in the process of technical writing and research report formatting, there is often a lack of effective communication. Users are usually not well-identified, understood, nor appealed to in report writing. Only rarely is the idea marketed so that the user understands how the new procedure can decrease expenses or improve productivity. Even though the idea itself may have been effectively communicated, the typical research report does not tell the user how to implement it.

Information Users

The daily operations of the construction business are demanding. Many managers are content to concentrate on the most pressing business at hand, and spend little or no time looking ahead to techniques that will allow the organization to remain competitive or to continue efficient operation. The transfer process is not consciously ignored but simply overwhelmed by more important problems.

There was no evidence of inadequate technical backgrounds in the user organizations; however, it was noted that the user generally rejected a report having mathematical calculations early in the text. This type of block on the part of the user seems to be caused by a lack of motivation. Government organizations are the only advocates of providing incentives for innovation, such as the U.S. Army Suggestion Program; however, even this program is of questionable value in the transfer process.

An innovative environment was clearly lacking in most construction organizations, perhaps because of the age and traditional conservatism of the industry. Amazingly, peer pressure stifled creative thought in a number of organizations. In one situation, by peer group convention, it was forbidden to talk about the job in any way that could affect numbers of workers on each pay scale. Many employees were reluctant to be innovative because they felt it might endanger job security.

Behavioral Blocks

Once an idea had been identified as having potential value to the organization, the most pervasive and widely observed block to further implementation was the human tendency to resist change. This was not an unexpected observation, but the depth of resistance in the construction industry was astounding. The extent of the resistance can probably be attributed to the sophistication and the profit (survival) orientation of the industry. The degree of resistance was particularly apparent when employees had been with the organization for a long time, and job security was a problem.

Resistance to change manifests itself in a variety of ways. For years, construction has been managed loosely, because foremen and supervisors were so experienced that few uncertainties affected operations materially, and resources were not critical. Since construction has become more complex and resources more dear, the demands of cost control and quality assurance have forced the managers to rely increasingly on automation and reporting (paperwork), topics which are not well received by the older construction supervisors. In addition, resistance to an idea occurs when it has not originated within the using organization. The tool described in the literature never seems to fit the user's situation.

3 TECHNIQUES FOR OVERCOMING TECHNOLOGY TRANSFER BLOCKS

General

During this study, it was noted that some of the organizations used a number of techniques which successfully innovate and implement new ideas. Although there were no established programs to accomplish technology transfer, the climate in several organizations was such that excellent transfer did occur.

The Transfer Mechanism

A generally successful technique for improving transfer was the technology "linker"[2] or "gatekeeper."[3] The linker is an individual or group of individuals who form the mechanism of transfer from the information source to the information user. Behavioral studies have characterized individuals with linker traits and those with "stabilizer"[4] traits. A linker is one who is innovative, maintains high credibility among his peers, is risk-conscious but not fearful, is cosmopolitan, and is interested in a broad range of disciplines and activities.

The linker is not necessarily a third party, but may be a member of the research or using organization. In every case studied for this investigation, one or more individuals served as linkers, not because it was part of their responsibility, but more because it was their natural personality function. Conversely, when linkers were not available or when strong stabilizers were present, technology transfer was stagnated. The role of the technology linker appears to be important and should be the object of further study.

Information Sources

The organizations which are successful in implementing new ideas are aggressive in their contacts with information sources. They subscribe to many magazines and journals, research newsletters, and documentation services such as the National Technical Information Service.

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2 Technology Transfer in Research and Development, J. A. Jolly and J. W. Creighton, eds. (Naval Postgraduate School, 1975), ADA033100.

3 R. G. Havelock and K. D. Benn, "An Exploratory Study of Knowledge Utilization," in G. Watson, Concepts of Social Change (NTL Institute for Applied Behavioral Science, 1967).

4 S. H. Claasen, Technology Transfer as Applied to Government Service Employees of the Naval Facility Engineering Command and Compared to Naval Officers of the Civil Engineering Corps, Thesis (Naval Postgraduate School, September 1973), AD#769813.

Employees at all levels are encouraged to attend conferences and symposia regularly and to enroll in continuing education, usually with the financial support of the organization.

Cooperative efforts between academic institutions and the organization are cultivated. One construction company has employed a university professor for nearly 10 years as a special assistant to the president; he works 1 day per week on special problems or ideas which the company wishes to pursue. They feel that he has repaid his cost tenfold. This is a very successful implementation of the linker concept in which the relationship results in a two-way communication path between the academic world and the practical application world.

Information Producers

Although user organizations want to learn about innovations, they can do little to overcome the problem of ineffective communication by researchers. Researchers can help alleviate this problem by first identifying who their audience is, and then carefully directing their explanations to that audience.

The writer should either avoid unnecessary mathematics, or should place them in annexes/appendices which are not crucial to the overall understanding of the ideas presented. Programmed text and technique user guides having appropriate example calculations can effectively replace sophisticated mathematical notation for certain audiences. If cost or productivity improvements are known to be a result of the new procedure, they should be clearly documented.

The typical writer's guide used by research organizations to insure uniformity and consistency of style should be carefully designed by communications experts. Many blocks to user understanding appear to be caused by poor research report formats.

Information Users

High-level management in successful organizations actively encouraged an innovative atmosphere for their employees. The most effective techniques for encouraging innovation were leadership example and clearly stated expectations for employees and middle management. Some managers were expected to devote at least 10 percent of their time to investigating future improvements. One company is actively attempting to use the advantages of the learning curve phenomenon by building a single product better and cheaper than its competitors.

Although most companies contacted do not realize it, they seek out individuals who have the typical linker attributes. The companies that implemented well typically maintained excellent employee relations.

There was a conscious effort to improve job security, even in a depressed market. Typically, a more secure individual feels confident in suggesting new concepts and becomes less resistant to change.

Resistance to Change

Resistance to change is a behavioral problem whose solution is not clear, even after years of research. To quote a cliche, "change is inevitable," a statement which is probably truer in the construction industry than in any other sector.

The classical three-step approach to fostering change is (1) to unfreeze the present level of thought, (2) to cause a move toward a new thought position, and (3) to freeze thought at that new level. Obviously, the first step is the most difficult and requires certain prerequisite conditions. The enlightened manager will seek education in the concepts and requirements for change both for the organization and for himself/herself. This will improve the chances for continued adoption of profitable developments.

4 CONCLUSIONS

The information obtained by this study indicates that the problem of management tool technology transfer in the construction industry is severe but not insurmountable. Some construction organizations, both within and outside the Government, successfully implement new ideas for increased profit or productivity.

A knowledge of the blocks to technology transfer can reduce their effect, since these blocks are predominantly behavioral in nature. Personality interactions, effective management, and open-minded approaches can overcome the blocks. Awareness of the problem is a good start to more effective technology transfer.

The concept of a technology linker is viable and useful in practical application. Linkers should be given more responsibility in the implementation process.

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APPENDIX A:

ORGANIZATIONS STUDIED OR CONTACTED DURING THIS STUDY

Associated General Contractors of America (The), Washington, D.C.

Department of Transportation, Washington, D.C.

Facilities Engineering Directorate (The), West Point, New York

General Services Administration, Washington, D.C.

Geupel - DeMars Construction, Inc., Indianapolis, Indiana

Guy F. Atkinson Construction, San Francisco, California

House Committee on Science and Technology (The), Washington, D.C.

Institute of Water Resources (The), Washington, D.C.

Luther Hill and Associates, Dallas, Texas

McKee Berger and Mansueto, Inc., New York, New York

National Science Foundation, Washington, D.C.

New York District of the U.S. Army Corps of Engineers, New York, New York

North Atlantic Division of the U.S. Army Corps of Engineers, New York

Tishman Construction, New York, New York

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