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ABSTRACT

An interdisciplinary research team investigated the field of educational research/development and innovation (R/D&I) in order to (1) develop an understanding of the nature, structure, and functioning of R&D as they interact with their environments; (2) develop an understanding of educational R&D and of the educational context in which it exists and with which it interacts; (3) develop an understanding of the applicability to educational R&D of models, technology, and experience found in other R&D sectors; and (4) develop an understanding of the basis for comparative analysis of R&D systems across sectors. Basic to the report is the concept of "contextual analysis," in which innovation is recognized as a total process of knowledge production and utilization, the aspects of which interact and cannot be adequately understood apart from this interaction. The report is divided into four sections: (1) the framework for a contextual analytical approach to R/D&I; (2) illustrative contextual analysis of two R/D&I sectors; (3) illustrative contextual analysis of selected feature issues; and (4) review of the report, and preview of the application of contextual analysis to more specific situations. (MB)

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CENTER FOR THE
INTERDISCIPLINARY STUDY
OF SCIENCE AND TECHNOLOGY

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS 60201

Comparative Research, Development And Innovation: With Implications For Education

Abridged Report For
The National Institute Of Education

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

April 1977

Michael Radnor
Harriet Spivak
Earl C. Young
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with the assistance of
Raymond J. Buckley

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ABRIDGED REPORT FOR
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PREFACE

One of the pressing issues for educational R & D is to build and integrate the field of educational R & D systems studies. To meet this need will require:

1. an understanding of the nature, structure and functioning of R & D systems as they interact with their environments;

2. an understanding of educational R & D and of the educational context in which it exists and with which it interacts;

3. in light of the above, an understanding of the applicability (or non-applicability) for educational R & D of the R & D models, technology and experience to be found in other sectors.

4. as is implied in the above, an understanding of the basis for comparative analysis of R & D systems across sectors.

It is to the above tasks which this report addresses itself, bringing to bear an interdisciplinary R & D perspectives of members of the research team at the Center for the Interdisciplinary Study of Science and Technology at Northwestern University (CISST).

This is an abridged version of a very much longer report (over 1200 pages) which is being revised into three seperate volumes. These later volumes will expand the discussion in this report by providing a comprehensive contextual analysis of the education sector and by including contextual and issue analyses not included in this report. Further, the later volumes will be written for specific audiences. One volume will be for R & D systems researchers, elaborating the contextual analytical framework and methodology and exploring its utility for identifying research issues and generating research agendas. A second volume will be for policy analysts and policy makers, describing the methodology in a manner useful to meet policy needs and illustrating the utility of the contextual analytical framework by presentation of policy analyses we have conducted for NIE and other agencies. A third volume will be directed to the educational R/D&I* community, providing a comprehensive analysis of the key aspects of the educational R/D&I system. An addendum to this volume will provide an extensive annotated bibliography of the educational R/D&I literature.

This present report will include the following:

Chapters One and Two (Section One) will provide a basic understanding of the process of contextual analysis for R/D&I.

- Chapter One will discuss the nature and bases for a contextual analytical approach and then will describe and discuss the CISST comparative contextual analytical framework.

- Chapter Two will then expand the discussion of the major aspects (which we will call "features") of an R/D&I context.

Chapters Three through Five (Section Two) will then provide illustrative detailed analysis of the contexts of selected sectors, using the CISST analytical framework.

- Chapter Three will focus on the education sector, and will summarize the discussion to be presented in more comprehensive detail in the later volume on educational R/D&I.

- Chapter Four will focus on the civilian aviation sector.

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*Research, Development and Innovation (R/D&I). As will be discussed in Chapter One, we use this term to describe the total process of innovation.

Chapter Five will provide a summarized illustration of a cross-sectoral comparative contextual analysis. The sectors included are education and civilian aviation (as discussed in this report); and health, law enforcement and industry (for which more detailed contextual analysis will be provided in one of the later volumes).

Chapters Six and Seven (Section Three) will illustrate how the contextual analytical approach may be used to analyze specific R/D&I issues.

Chapter Six will focus on the institutional base of R/D&I systems, with particular attention being given to how the R/D&I functions* are "clustered" together within and among the institutions of R/D&I systems.

Chapter Seven will focus on the issue of entrepeneurship as this relates to the historical and current state of development of R/D&I systems.

Chapter Eight and the Appendix (Section Four) provide, in effect, a "look back" and a "look ahead".

Chapter Eight (the Conclusion chapter) will briefly review this report and suggest ways the contextual analytical approach may be utilized.

The Appendix will provide an excerpt from one policy issue analysis and brief descriptions of other issue areas where we have thus far utilized (or proposed to utilize) the contextual analytical approach discussed in this report.

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*The specific meaning we attach to the term "R/D&I functions" will be discussed in Chapter One.

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ACKNOWLEDGEMENTS

We wish to acknowledge the invaluable assistance provided in the preparation of this report by our administrative assistant, Mrs. Elizabeth N. Olmsted, whose help enabled us to prepare this report at this time.

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SECTION ONE

THE FRAMEWORK FOR A CONTEXTUAL ANALYTICAL APPROACH TO R/D&I

CHAPTER ONE

THE COMPARATIVE ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

THE COMPARATIVE ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

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CHAPTER ONE

THE COMPARATIVE CONTEXTUAL ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION SYSTEMS: AN OVERVIEW

I. INTRODUCTION

One of the central issues in education is the need to develop our knowledge and skills in educational R&D policy making and management. To respond adequately to this need requires at least the following:

1. an adequate description of educational R&D as it currently exists;
2. identification of those aspects of R&D which are generic; i.e., which are in some way common across different sectors or fields (e.g., health, education, aerospace, etc.) -- if indeed such generic characteristics do exist;
3. identification of those aspects of educational R&D which are sectoral; i.e., specific to the nature of education and educational R&D (and why);
4. determining, in light of the above, why educational R&D systems have the character they do and function or operate in the ways in which we observe them to do.

When the above analyses are made and interacted with each other, we can begin to gain insight into policies and strategies which are specifically relevant to educational R&D, while at the same time allowing relevant transfer of R&D management technology and experience from non-educational sectors.

This project focuses primarily on the second of the above points (though one of our sectoral analyses will be of education). That is to say, the task of this project is to develop the outline of a framework for comparative analysis which will enable us to understand observed differences and/or commonalities in R&D systems across the various sectors. It is further the task of this project to demonstrate the utility of such an analytical frame-

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work in terms both of policy making and management and of transfer of relevant technologies and experience across sectors.

Policy making and management in R&D must sail the narrow straits between Charybdis and Scylla, with the danger of non-relevant generalizations on the one side and the danger of reinvention of well-established principles on the other side. At present, there does not exist the analytical framework for R&D which could map this narrow channel for policy making/management navigators. It is our hope to provide at least the basic outline of such a map.

II. SOME INITIAL CONSIDERATIONS

Before beginning to develop a framework for comparative analysis of R/D&I systems, it is important to provide some initial background concepts and understandings from which we will be working.

1. Research, Development and Innovation -- R/D&I as a Total Process of Innovation

From this point on, we will be using the term "Research, Development and Innovation (R/D&I)" instead of the more common term "Research and Development (R&D)." Our reason is simple. The term "R&D" tends to imply a very narrow part of the total spectrum of functions and activities involved in a total process of innovation. Research and development are essentially "pre-user" aspects of the total innovation process. A total innovation process <u>also</u> includes such "post-development" functions such as production, dissemination (a key <u>linking</u> function) and acquisition/implementation/utilization (<u>user</u> functions). A total innovation process also recognizes that users may also be innovators.

Thus, a complete conceptualization of an R/D&I system (i.e., a total innovation process) requires that we recognize it as spanning the total knowledge production (KP) to knowledge utilization (KU) spectrum. Thus, this total spectrum of R/D&I activities will include not only research (both basic and applied) and development, but also production, dissemination, acquisition, implementation, utilization, evaluation research, etc. Further, we must also have an understanding of the operative conditions that exist within and affect the R/D&I system (e.g.: the state of system maturity; the personnel base; funding levels and patterns; etc.). Finally, we must also take into account the environment with which the R/D&I system interacts.

Such a complete conceptualization of a total innovation (R/D&I) process recognizes the many variations of innovation processes -- for example: the role of "creative insight" by an individual apart from any research or development (e.g.: by an educational practitioner); or that a specific function (e.g.: research) may in practice exist in a rather isolated fashion. However, conceptualization of a total R/D&I process will enable us to evaluate the overall role and effects of such various types of innovation activities.

Thus, we will use the term "R/D&I".

2. The Process for Developing a Comparative Analytical Framework

The process we have used in developing the comparative analytical framework to be presented here has been an iterative process. Thus, the relevant literature and the extensive experience of CISST personnel and Northwestern University was used to make a "first cut", tentative identification of key variables (which we will later label as "features") which would seem to be common (generic) to R/D&I systems. From these key variables (features) we developed the comparative analytical framework which we are now describing. In turn, this framework was used for a more detailed and systematic examination of several sectors and of several features (and sub-parts of features).

The above process, though described in rather linear fashion, was quite iterative -- with each part of the process being repeated several times as new insights and understandings were gained. For ease of presentation here, we will generally use a step-by-step descriptive process which reflects the result of these iterations.

3. The Emergent Nature of Real-World R/D&I Systems

It is important to note at the outset that a "real-world" R/D&I system emerges as an interactive "working out" of generic R/D&I characteristics within a specific sectoral context -- whether by deliberate design or not.

Thus, both the researcher and the decision maker must understand that R/D&I system features, issues and management policies/strategies will have both generic and sectoral dimensions, and that these will all be in interaction with each other.

For the decision maker, the importance of understanding this "emergent" nature of R/D&I systems is threefold.

1. An understanding of the generic characteristics of R/D&I systems enables the decision maker to "zero in" on the areas of the sectoral context where the critical issues are likely to be and where in-depth analysis of the sectoral context is needed.

2. An understanding of the nature and uniqueness of one's sectoral context provides a basis for learning from R/D&I systems in other sectors and for determining the adaptability/transferability of knowledge, methods, techniques, innovations, etc., from R/D&I systems in other sectors.

3. From an understanding of the interaction between generic and sectoral characteristics, the decision maker has a basis for developing policies and strategies which are both generically functional and sector-specific.

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For the purposes of this study, the "emergent" nature of R/D&I systems will allow us to make cross-sectoral comparisons of R/D&I systems. To the degree that R/D&I system issues and characteristics have common aspects across sectors, we may identify generic characteristics of R/D&I systems. Contrarily, to the degree that R/D&I system issues and characteristics vary across sectors, we will have begun a description of the sectoral R/D&I system characteristics.

We may further note that this "emergent" perspective permits both deductive and inductive analysis. That is, we may start with the generic understanding of the R/D&I context (i.e., the features), and through interactive analysis with the sectoral context, identify "real-world" issues, policies, strategies. Or conversely, we may analyze a "real world" issue, policy or strategy (e.g.: the impact of specific program selection) in the light of sectoral and generic R/D&I system characteristics.

4. Some Key Terminology

It will be helpful at this point to introduce briefly some key terminology we will be using throughout this report. We will save fuller explication for later.

A. Sector -- A field of interrelated activities/institutions (e.g.: health; industry; aerospace; law enforcement; education) which is identifiable as such for practical purposes (e.g.: for funding, policy decisions, analysis).

Of course, there will be sub-sectors within a sector (e.g.: the drug sub-sector of the health sector). Also, there will be institutions which may span several sectors (e.g.: communication equipment for several sectors).

Thus, definition or delineation of a "sector" may vary according to the practical purposes of the policy maker, researcher, etc.

B. <u>Feature</u> -- An identifiable aspect of the total R/D&I process which is useful for analytical and/or decision making purposes (e.g.: the R/D&I system's environment; the personnel base; the network of institutions; research; development; dissemination; utilization; etc.)

C. <u>Function</u> -- A specific type of R/D&I system activity which describes <u>what the system does to produce and utilize knowledge</u> and which may thus be considered an integral part of a total innovation process (e.g.: development; implementation). The various functions form a sub-set of the total set of features.

D. <u>Issue</u> -- A specific aspect of a feature which is of concern to the researcher, analyst, policy maker or decision maker (e.g.: "sources of information" as a specific aspect of the information flow feature).

E. <u>Context</u> -- The total set of features which provides an interactive framework within which a feature or an issue must be analyzed. Thus, for example, if a specific function (e.g.: development) is to be analyzed, its context would include all other features.

5. A Theoretical Framework as an Access to Analysis

It is important to understand that all R/D&I systems consist of a complex variety of features which must be understood individually and in interaction before a full understanding of an R/D&I system as a whole can be developed. It is this very complexity which makes necessary the development of an analytica framework within which this complexity may be analyzed. At the same time, we must emphasize that the analytical framework we are presenting is, precisely, a tool for analysis. Thus, in presenting an analytical framework, we make no claim for its completeness, absoluteness, or definitiveness. Rather, in its form and content, the analytical framework is presented as a <u>useful</u> way of gaining access into an analytical process -- not as some esoteric "model to end all models".

Specifically, we would note the following.

A. The Listing of Features

We have selected nineteen "features" to form the basis of an analytical framework*. Different names could be given to these features; different features could be emphasized; slightly different modifications of the nature of a feature could be made; other features could be added. Indeed, we assume that a different listing of features and/or issues will at times be useful as new insights are gained and/or as features not included here have significant relevance to a specific analysis or policy issue. The way we have categorized the features should facilitate such modifications in the total list of features and issues.

B. R/D&I System Configurations

In presenting our analytical framework, we will use a linear array of the R/D&I process. This is done solely for ease of presentation. As will be seen, we fully recognize (indeed, we emphasize) the interactive, often non-linear nature of the different features (both in theory and in reality) of the total R/D&I process. The array of features (and in particular the functions) presented here could be re-labeled, subdivided, clustered, organized in parallel streams, connected with various feedbacks and cyclical loops, etc. Thus, our use of a linear array of features is simply an artifact of presentation -- and the reader should treat it as such.

*See pages 25 - 27.

C. The Configuration of Functions: An Emergent Dependent Issue

It will perhaps be helpful here to carry this discussion of configurations a little further, specifically with respect to R/D&I system functions.

A variety of configurations of R/D&I system functions is not only possible -- such variety actually exists in an indeed may be mandated by the specific nature of the environment and operative system conditions existing within a specific sector. Thus, in some instances, we might find the various functions rather precisely segmented. In other instances, we might find the various functions rather precisely segmented. In yet other instances, we might find the entire R/D&I process occuring within a single institution, or even within a single person.

Further, we might find R/D&I systems interacting with each other. Thus, a specific real-world organization (e.g.: a federal R&D laboratory; a book publisher) may play roles in several different sectors (e.g.: health; energy; etc.).

Thus, while we utilize a linear array of R/D&I functions for purposes of presentation, we will treat the configuration of functions as an emergent dependent issue.

III. R/D&I SYSTEMS: SECTORAL DIFFERENCES AND GENERIC COMMONALITIES

1. Defining a "Sector"

We have up to this point identified a "sector" in terms of a somewhat vague (but hopefully somewhat reasonable) concept of a "field of interrelated activities/institutions" (e.g.: the health field; the education field; the field of industry; etc.). The typical question we will be posing is: How do R/D&I systems vary across sectors?

There are several problems with this question. We lack any substantial basis for knowing how or why to distinguish one sector from another -- and there are very obviously also major differences within what we call sectors. Thus, there may be greater similarities between some of the regulated industries and various government agencies than between regulated industries and other industrial firms. Service firms operate in quite different ways from manufacturing firms. Some hospitals are private for profit; others are public. And so on. If we take a purely empirical perspective and examine the R/D&I systems across the commonly differentiated sectors (industry, health, education, etc.) we quickly encounter the problem of having to deal with many unexplainable variances within sectors and across supposedly similar sectors. We also encounter similarities across supposedly different sectors. As we attempt to unravel these anomalies we inevitably move toward the use of more complex typologies of organizations, sectors, products, personnel, etc., specific recognition of historical developmental phases; consideration of differences in the state of knowledge and technology; etc.

Indeed, precisely because the definition of a real-world "sector" is an imprecise science, it is necessary to take into account the various complexities involved. Utilized in its fullest possible way, the analytical framework we are presenting would merely take this process of ever-increasing complexity to its logical conclusion. Needless to say, we are not advocating such an infeasible ultimate strategy.

2. The Necessity of a Sectoral Basis of Comparison

To abandon a sectoral basis for comparative analysis simply because of the inherent degree of vagueness and complexity might be theoretically interesting. It would not be useful.

Society is organized and operated within such sectors to an important degree. If we are to be helpful to policy makers, managers and other participants we must be able to relate ourselves to the affairs of such specific sectors. Thus, our objective will be to attempt to understand, in relation to any specific issue under investigation, what complex of contextual conditions has what impact; and to which sector (or part of a sector) such a complex of conditions can be associated.

We do not, for example, make the a priori assumption that the R/D&I flow of personnel will vary across all systems, or at all times within a sector such as health, education, agriculture, industry, etc. Rather we wish first to know what contextual conditions influence this flow, and then to determine in what ways sectors (or parts of sectors) vary across these contextual conditions.

In this way it will be possible to explain why similarities and differences in personnel flow appear across and within sectors. With this perspective we can also now hope to address ourselves to the question of how and why differences do appear for a given area over time. Inevitably this makes the process of comparative analysis complex, but, we believe, for the first time feasible.

3. Existing R/D&I System Variations

In attempting to develop a theoretical analytical framework for R/D&I systems, one is immediately struck by the immense amount of observable variety in real-world R/D&I systems. Existing R/D&I systems vary in such matters as: clusterings of functions within a single organization (or even within a single organizational unit); existence and strength of institutional networks; overall level of system maturity; susceptibility to political influence; types of dissemination mechanisms and strategies; use and effectiveness of various management technologies; etc.

R/D&I systems vary across sectors. Thus, for example, the R/D&I system in aerospace differs significantly from the R/D&I system in education. But the issues are complicated even further because R/D&I systems also vary <u>within</u> a single sector. Thus, for example, within the private industrial world we encounter rather different R/D&I systems for the oil and T.V. industries. In health, the R/D&I systems for drugs and surgical procedures will vary.

A. Illustrations of R/D&I System Variations Across Sectors

To illustrate the kinds of problems and issues that arise from such intra/inter-sectoral variances, let us look very briefly at the ways in which R/D&I functions are organized (in groupings or separately) in the real-world institutions which are to be found in the various sectors -- i.e., comparing how a variety of functions (research, development, dissemination, etc.) are encompassed in single or multiple organizations or organizational units, and how this differs across sectors. Given the present concern within education with institution building, this would seem to be an important issue for educational R/D&I.

We will briefly look at the organization of functions in the following three sectors:

1. Industry -- specifically the civilian aviation industry;

2. Health -- specifically the drug field;

3. Education -- specifically the curriculum and materials area.

In the civilian aviation industry the R/D&I system is organized in a relatively linear, function-to-function process from basic knowledge production (KP) to knowledge utilization (KU). The R/D&I system is relatively highly differentiated and each organizational unit or department is highly specialized. The stages of the R/D&I system are well developed and clearly defined. The functional clusters to be observed are those built around adjacent sets on the KP to KU continuum.

In the drug field we do not find such linear, function-to-function organization. Rather, we encounter "loops", with functions from the knowledge production stages being associated with production, implementation and utilization functions, all within single organizations. Most specifically, medical practitioners are found having significant roles and influence at many stages of the process.

In the world of education, and specifically in curriculum and materials development and utilization, we observe a system that is characterized by highly diffused arrangements of R/D&I functions. There is a considerable amount of grouping of functions to be observed, with elements of applied research sometimes linked (sometimes not) with development and utilization. There are often gaps, with R/D&I functions being subsumed (but not articulated) into other functions.

B. Some Additional R/D&I System Sectoral Variances

R/D&I systems frequently are not sectorally "pure". Thus, a specific organization may be playing roles for a number of fields. For example, a publishing company may be involved in producing materials used in the worlds of health, education, law enforcement and business. Such sector-spanning institutions may play an important cross-sectoral linkage role, as well as playing the specific role that they do in a given sector.

We may also note that a given sector may contain several relatively distinct R/D&I systems.

4. Commonalities Among Existing R/D&I Systems

In spite of the immense amount of observable variety among existing R/D&I systems, these systems nonetheless do also seem to exhibit common characteristics -- characteristics that imply the existence of generic features of R/D&I systems.

From a broad, overview perspective, we may note that all R/D&I systems involve some rather basic, common functions, such as research, development, production, dissemination, utilization, etc. The specific form, manner or configuration of these functions may vary across sectors, but the functions themselves appear to be inherent in the overall innovation process of an R/D&I system.

We may further note that for any single R/D&I function, there appear to be characteristics which are common (i.e., generic) to that function both across and within sectors. For example, the basic research function involves a high level of uncertainty and unpredictability; involves extending the limits of the existing state of the art (a criteria for "excellence" in basic research); often involves a long time-line (10, 20, even 50 years). These characteristics, if indeed generic, have strong implications for policy making and management in R/D&I systems.

In contrast, the function of development involves a significantly lower degree of uncertainty and unpredictability; is concerned with utility and "product specifications" instead of "ultimate" qualities; requires less highly specialized and more interdisciplinary personnel; and generally tends to have a short to moderate time-line (usually at least 3 to 5 years, sometimes longer). These characteristics, if indeed generic, will have strong implications for policy making and management in R/D&I systems -- but the implications will be significantly different from the implications relevant to basic research. Further, these differences between the basic research and development functions (and other functions as well) will have strong policy making/management implications concerning the integration/coordination/orchestration of the various R/D&I system functions.

5. Sector Vs. Generic: The Need for a Framework for Comparative Analysis of R/D&I Systems

The discussion thus far begins to indicate the type of questions and issues which are important to policy making and management in R/D&I systems. For example:

How can we identify when cross-sectoral differences represent significant gaps and/or inappropriate states (i.e., the absence or wrong application of key generic aspects of R/D&I) -- and when do these differences represent reasonable adaptation to specific sectoral contexts?

Why do certain management approaches (e.g.: PERT) seem to work well in one sector (aviation) and poorly in another (education)?

What policies and management approaches are most appropriate to a given R/D&I function in a specific sectoral context?

To answer such questions, it becomes necessary for us to try to understand how the requirements for R/D&I systems emerge from the interaction between generic characteristics of R/D&I systems on the one hand and the specific sectoral R/D&I context on the other hand. We must then try to understand how generic commonality and sectoral variety in R/D&I systems lead to varying policy and management issues and requirements within and across sectoral R/D&I systems.

Developing such an understanding has come to be recognized as one of the most critical needs of innovation studies at this time. In a recent review of current knowledge on technological innovation, Kelly and Kranzberg [1] have commented (based on the commissioned contributions of a dozen leading researchers in this field):

"The literature on organized innovation consists largely of narrowly-focused, piecemeal, non-cumulative empirical studies. Hence the complex interrelations among organizational structure, function, and orientation toward R&D are not well understood.

> There is a critical need for higher-level, integrative theories and models which can guide the empirical studies and lead to cumulative results, both explanatory and normative. We see an immediate need for an iterative, interactive relationship between theoretical and empirical research....".

6. Three Central Questions of this Analysis

From the discussion thus far, it becomes obvious that there are really three basic questions around which this analysis is (and must be) focused:

1. Can R/D&I systems be described in generic terms?

2. Can an analytical framework be developed which will enable us to identify and differentiate between generic and sectoral characteristics of R/D&I systems?

3. Will the analytical framework and subsequent generic and sectoral descriptions be useful to the policy making/management decision makers? That is, can the generic/sectoral descriptions be brought down to policy and management relevant levels of detail, and yet still be mapped back into the more general analytical framework?

Real-world R/D&I systems reflect the variety and complexity that results from the interaction of generic and sector-specific dynamics. Thus, generic R/D&I characteristics cannot be identified simply by cataloguing real-world R/D&I institutions, processes, characteristics, issues, etc. -- now by creating empirically based models of R/D&I systems. Both processes lack mechanisms (analytical frameworks) with which to distinguish between that which is generic from that which is sector-specific.

Thus, what is needed is such an analytical framework, which will allow one to distinguish between the generic and sector-specific characteristics and issues of real-world R/D&I systems. This framework must recognize that the context of an R/D&I system is the product of a complex interaction of all system features and of generic and sectoral dynamics.

A framework which included a complete description of all possible contextual features and issues (and their interactions) would be quite complex -- and far beyond the scope of this study. Nonetheless, we shall attempt to provide the outline of such a framework and provide some illustrations of its usage.

In light of the above comments, we believe that a cross-sectoral method of analysis will provide an analytical framework within which generic and sectoral issues may be identified, differentiated and illustrated in a manner useful both to the analyst and to the decision maker.

It is to this task that we now turn.

IV. A FRAMEWORK FOR COMPARATIVE ANALYSIS OF R/D&I SYSTEMS

1. The Perspective of General Systems Theory

The framework presented here for the analysis of R/D&I systems has been drawn from the general systems theory literature, as exemplified by such authors as Ludwig Von Bertalannffy[3], and James G. Miller[2]. Without attempting to present an exposition of this perspective, we simply note that we have adopted the central elements of their framework for describing the structure and functioning of living systems.

Thus, we will attempt to analyze R/D&I systems in terms of how they interact with their environments; their central elements or sub-systems; the mechanisms that link them together; internal system structures; input-output systems -- as well as such other system conditions as age and state of developmental maturity.

A. System Definition

An important question is that of system definition: What is to be considered within the R/D&I system(and within which part of the system) and what is in the environment? The framework we are presenting does not contain abrupt boundary notions. What is considered within or external to the system is a matter of degree and will depend on the focus and purpose of the analysis. Further, an R/D&I system may be "defined" either broadly or narrowly, depending upon the contextual situation and the needs of analysis. In the broadest sense, a particular R/D&I "system" may (for practical purposes) comprise most of a sector. In the narrower sense, a single institution may encompass virtually all aspects of an R/D&I "system". In the latter instance, we may indeed find several institutional R/D&I "systems" existing within (and being a part of) a larger R/D&I "system" within a particular sector.

The critical point to be noted here is that the framework for comparative analysis of R/D&I systems being suggested here is not meant to be limited to a rigid conceptualization about boundary notions, size or scope of what is/is not an R/D&I system. Rather, the definition of the relevant R/D&I systems (as is true of all other aspects of the analytical framework) is based on creating an opportunity to frame key questions related to the focus of the issue analyses relevant to policy/decision makers and researchers.

B. Innovation and Operating Systems

While we have just noted that we do not want to imply rigid boundary conceptions of what is and is not "within" an R/D&I system, it is equally important not to make the boundaries of an R/D&I system so broad and/or vague that the R/D&I system includes "everything" (and thus becomes a meaningless concept). Thus, it is important to distinguish between those aspects of a sector which deal in some way with a process of innovation (and thus are a part of a total R/D&I "system") and those aspects of a sector which are not involved in a process of innovation (and thus are not part of a total R/D&I "system"). These latter aspects of a sector may be called the "operating system". Nevertheless, we will need to be aware of ways in which the "operating" system affects (or is affected by) the "R/D&I" system.

In light of the previous discussion of system definition, we should note here that the extent of "overlap" between the R/D&I and operating systems may vary significantly across sectors. Thus, for example, the effort to land a man on the moon in the 1960's involved virtually all aspects of the system in the process of innovation. In contrast, in the health or agricultural sectors, there is a large operating system which may indeed be involved at times with an innovation process but whose primary role is clearly at the "operational" level.

C. Extent of R/D&I System Linkage

Another aspect of the "system" concept that must be considered here is the extent to which the various institutions within an R/D&I system are (or are not) coherently and strongly linked together. Simply put, while we do consider a set of institutions to comprise an R/D&I system (because of the roles they play within the total process of innovation), we do not presume that they are in fact coherently linked together in "appropriate" ways or that existing linkages are strong. Indeed, the opposite may be true in any given context - - and there may be "gaps" in the system's linkages. Indeed, the critical issues here are precisely the nature, strength and appropriateness of the linkages (or lack thereof) which do exist.

D. Maturation (State of Development)

It is important that we understand R/D&I systems from an "organic" perspective. That is to say, that they "emerge" over time, that they go through/ may be at different stages or levels of development (maturation). Further, different institutions and/or different functions within an R/D&I system may differ in terms of their respective stages or level of development. The importance of this concept of maturation may be seen in at least the following ways:

1. The needs of an R/D&I system may be different when the system is young and immature than when it is established and mature.

2. Since R/D&I systems may mature (or decline) over time, their needs may change over time.

3. Policies, strategies and mechanisms which are relevant for an R/D&I system which is young and immature may be irrelevant (even dysfunctional) for an R/D&I system which is established and mature.

4. Further, different policies/strategies/mechanisms may be needed when the R/D&I institutions and/or functions are at different stages of development than when their levels of development are "in balance".

We need, however, to understand that the concrete meaning of "maturation" may differ significantly across sectors. Thus, for example, even at a "mature" stage of development we would not expect to find the same level of clarity and certainty in the evaluation research function in a social science sector such as education as we would in a physical science sector. The realization of inherent differences between sectors will be important if we are to avoid making incorrect comparisons of (and developing the wrong expectations for) one R/D&I system in relation to other R/D&I systems.

2. A Framework for "Mid-Level" Analysis

Our comparative analytical framework serves to focus attention on a somewhat neglected area of research nd analysis, sometimes referred to as "mid-level" or "mid-range". As used here, this "mid-level" refers to research and analysis which is somewhere between the broad level of general theory and the narrow level of specific cases.

At the general theory level, the purpose of research and analysis is to develop concepts and relationships which serve to describe all situations (i.e., theories). The approach at this level is to develop processes of research and analysis which will uncover the broadly generalizable concepts and relationships. While important, general level theory lacks the specificity which is needed by policy and decision makers.

At the specific case level, the purpose of research and analysis is to discover and demonstrate the uniqueness of each situation, and the approach to research and analysis is designed specifically to uncover such uniqueness. At this level, research and analysis tends to lack bases for generalizability. Thus, this level of research and analysis also has limited value for policy and decision makers.

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Our comparative analytical framework utilizes a disciplined configurative <u>approach</u> that will permit systematic comparison of various sectors or policy/ strategy issues. The <u>purpose</u> is to develop appropriate areas of generalizabilit which allow one to take into account the uniqueness of specific situations.

3. Describing R/D&I Systems in Terms of Their Interactive Features

In developing a theoretical framework, we have identified nineteen key R/D&I system features which we believe will be helpful both to the researcher and to the decision maker (see Figure 1). For simplicity of presentation, we have grouped these nineteen features into the following categorical framework (using a general systems theory approach):

1. The R/D&I System's <u>Environment</u>

   This category will include those features which are external to the R/D&I system itself, but which may nonetheless impinge upon and affect the system -- and, alternatively, which the R/D&I system may affect (e.g.: social, legal, political, economic, technological environments).

2. <u>Operative System Conditions</u>

   This category will include features internal to the R/D&I system which affect the way the system operates but which are not activities by which the system creates or utilizes knowledge. These features will thus include general system conditions (e.g.: historical development), aspects of system management (e.g.: administrative processes) and system inputs and outputs (e.g.: personnel base).

Typical Comparative Features

I. ENVIRONMENT	1. Environments of the R/D&I System
II. OPERATIVE SYSTEM CONDITIONS	
SYSTEM	2. Historical Development 3. Institutional Base (Network of Institutions)
SYSTEM MANAGEMENT	4. Goals, Policies, Strategies 5. Administrative Processes
SYSTEM INPUTS AND OUTPUTS	6. Personnel Base 7. Funding 8. Information Flow 9. Innovations
III. R/D&I FUNCTIONS	10. Need Identification 11. Generation/Research 12. Development 13. Production 14. Marketing/Distribution/Dissemination/Diffusion 15. Acquisition 16. Implementation and Utilization 17. Support Services 18. Evaluation Research
IV. R/D&I RESEARCH	19. Research on R/D&I

Figure 1

Comparative R/D&I System Features

3. R/D&I Functions

This category will include those features which we would consider to be an integral part of a knowledge production to knowledge utilization process continuum -- i.e., what the system does to create and utilize knowledge.

Additionally, we have included an overview feature: Research on R/D&I. This will include any kind of research done about any aspect of the system (any of the features or feature issues; any element of the system such as a particular institution or set of institutions; etc.). The results of such research, in effect, provide the data base for analysis of the other features.

Within each feature, a number of relevant issues may be identified. An expanded discussion of these nineteen key R/D&I features and illustrative issues associated with each feature is provided in Chapter Two.

A different listing or arrangement of features and issues could, of course, be developed -- as we noted earlier. What is important is to recognize, identify and analyze the potiential or actual effects these various features may have (separately and/or in inter-action) on the total R/D&I system.

4. The Context of an R/D&I System

Taken together, the totality of the R/D&I system features and issues forms an interactive context in which analysis and decision making must be performed. The way an R/D&I system has developed over time in its sectoral environment; the types of institutions that have emerged; the character of the work and technologies; the personnel involved in each of the functions and institutions; etc. -- all contribute interactively to the totality of an R/D&I system's context.

For example, how an R/D&I system is structured will be influenced by such factors as the social, political and economic environments of the institutions that constitute the R/D&I system; by the degree of system institutionalization; by the nature of the work to be performed; by the history and state of the system's development; by the nature of the system's personnel base; etc. But in turn, these same variables will also be influenced by the structure of the R/D&I system. Such is the interactive nature of the R/D&I system context -- each R/D&I system feature acts both as an independent variable (as part of the total system context, affecting the other parts of the system) and as a dependent variable (which may be a focal concern for analysis and decision making).

In any given instance, analysis or decision making will, of course, be focused on some subset of contextual features or issues (or even on a single feature or a single issue of a feature). Such a narrowing of focus is necessary to bring the analytical/decision processes down to manageable and meaningful levels. Indeed, it is important to recognize that each feature has important characteristics which do distinguish one feature from another -- differential characteristics which often have important implications for both analysis and decision making.

However, the consideration of any single feature (or issue) must take into account the interaction of that specific feature with all other features -- i.e., one must consider a single feature or issue within the richness of its total context. To try to analyze any single feature (or issue) without considering its contextual interaction would not only be inadequate -- it would likely be quite dysfunctional, leading to wrong conclusions by the analyst and to wrong decisions by the decision maker. Such is the interdependence within an interactive living system.

Therefore a context has to be understood as the intersection of the effects or influences of each of the system features. If we wish to understand the character and managerial requirements of a given feature or issue (e.g.: the personnel base) it will be necessary to view this feature against the background of all other elements or features of the system in its context. By the same token, if we are concerned with a sub-issue within the personnel base feature (e.g.: the flow rate of certain types of personnel in and out of the system), then we would also have to include all the other aspects of the personnel base feature (e.g.: the types and levels of professionalism) as part of the relevant context for that sub-issue.

5. A Framework for a Comparative Sectoral Analysis of R/D&I Systems

In order to identify and differentiate between generic and sector-specific characterstics of R/D&I systems, it is necessary to do a cross-sectoral comparative analysis of R/D&I systems within their various specific sectoral contexts. This we will do illustratively in the later chapters of this report. The literature on R/D&I and the extensive research experience of our research group at CISST and Northwestern University relevant to R/D&I will provide the basic data for this comparative sectoral analysis.

However, we must first provide a framework within which to do such a cross-sectoral comparative analysis. We have already discussed the basic elements of this framework: features and issues, context and sectors. It is now the task to describe how these elements can be brought together to form a comparative analytical framework. This we will do in a step-by-step fashion, and we will distinguish between the comparative analytical frameworks useful for researchers and for decision makers.

A. A Focused Process of Analysis

To attempt to analyze simultaneously all R/D&I system features, characteristics, issues, etc. would be impossibly voluminous and complex -- even within a single sector. Similarly, it would be impractical to attempt an analysis of even a single feature across all possible sectors. Out of sheer necessity, it would be necessary to narrow the focus of analysis. This may be done by focusing on a specific R/D&I system feature or issue across a selected set of sectors. This narrowing of focus will enable us to identify the important characteristics of an R/D&I system feature or issue.

PROCESS FOR NARROWING THE FOCUS OF ANALYSIS		ILLUSTRATION
Step 1.	Select a feature for analysis which is relevant to the general area of concern	Features 1. Environment 2. Historical Development 3. Institutional Base 4. Goals, Policies, Strategies 10. Need Identification 18. Evaluation Research
Step 2.	List relevant issues of the selected feature	3. Institutional Base Institutions Institutional Roles Institutional Characteristics System Structure System Configuration Inter-Institutional Linkages
Step 3.	Select issue (or issues) which will likely contribute most to the general area of concern	
Step 4.	List relevant sub-issues	3. Institutional Base System Structure Inter-Institutional Linkages Linkage Characteristics Interface Structure Linkage Consequences
Step 5.	Select sub-issue(s) which will likely contribute most to the general area of concern	
Step 6.	Analyze the sub-issue	3. Institutional Base System Structure Inter-Institutional Linkages Linkage Consequences

Figure 2

An Example of the Process in Narrowing the Focus of Analysis

Figure 2 illustrates how the focus of analysis may be narrowed in successive steps until a level of analysis is reached where the analysis is sufficiently narrowed to be feasible yet still robust enough to permit meaningful analysis. Thus, the process narrowing the focus of analysis improves the "resolution" of what initially is likely to be a somewhat vague, "blurry" picture of a general area of concern about R/D&I systems. Of course, how broad or narrow the focus of analysis should be depends upon the purpose of the analysis.

B. A Cumulative Process of Analysis

Obviously, the analysis of a single feature or issue would not give us a full picture of R/D&I systems. Thus, separate analyses must be made of a range of features and issues -- analyses which though done separately would cumulatively provide a fuller picture of R/D&I systems. Cumulatively, these separate analyses will enable us to identify similarities and differences (a) among the features and (b) across sectors. Which and how many features and issues (and in how many sectors) are to be so analyzed will be determined by such factors as: time limitations; availability of data; the interest of the researcher, analyst, or the decision maker; or the specific purposes for which an analysis is needed. Of course, the ideal would be cumulative analyses of all possible features and issues across all possible sectors -- but as this is unrealistic (and probably not necessary), selections must be made.

C. Interactive Analysis by Context

Having chosen a feature or issue to analyse comparatively across sectors, it is necessary that the analysis be done as a <u>contextual</u> analysis. That is to say, while any given feature may have its own particular characteristics, the feature is a part of an interactive system. Each feature affects and is affected by <u>all</u> the other features (i.e.: context) of an interactive R/D&I system -- and no single feature can be adequately understood apart from its interaction with the other system features.

The interaction involved in a contextual analysis has a very important role. In essence, it keeps the analysis of a selected feature or issue in proper perspective relative to the overall picture of the R/D&I system. It guards against the danger that the feature or issue being analyzed (which is only a part of the total R/D&I picture) might be treated as if it were isolated and independent.

D. Delineation of Generic and Sectoral Characteristics

When a feature or issue is contextually analyzed across several sectors, it will become possible to identify similarities (i.e., generic characteristics) and differences (i.e., sectoral characteristics) of the feature or issue across sectors. While this identification of generic and sectoral characteristics must be considered tentative at this point in time, at least there will be findings which can be subjected to more scrutinizing analysis and empirical verification.

E. An Iterative Process

We must note at this point that the comparative analytical framework we have just described is an iterative -- not a unidirectional -- process. While the initial flow of the process is from sectoral contextual examination to identification of generic and sectoral characteristics, reversing the process is also important. That is, the generic and sectoral characteristics that are identified should provide a fresh perspective from which to examine the sectoral context.

This helps to satisfy the point made earlier by Kelly and Kransberg(1) that we have "...an immediate need for an iterative interactive relationship between theoretical and emperical research".

F. Summary

Figure 3 summarizes the above discussion of the comparative analytical framework.

6. Agency Use of the Comparative Analytical Framework

Thus far, we have described a comparative analytical framework for identifying generic and sectoral R/D&I system characteristics. While this is sufficient for research purposes, we need to take the process one step further in order that the comparative analytical framework be useful for the decision maker -- that is, using the framework to identify and evaluate policy and strategy options. To do this, we simply modify the sectoral, analytical framework (described in Figure 3).

Figure 4 describes the analytical framework which would be useful for decision makers. As figure 4 indicates, this analytical framework remains:

1. a focused, cumulative process of analysis (though now the focal point of analysis may also include policies and strategies -- a useful addition for the decision maker);
2. an interactive analysis by context; and
3. an iterative process of analysis.

However, we no longer focus on a cross-sectoral comparative analysis per se (though of course we do use the available cross-sectoral comparative data as relevant).

Instead, we now focus upon an iterative analysis of:

1. generic R/D&I system characteristics (which have been identified through the cross-sectoral process of comparative analysis);
2. sectoral contextual characteristics of the specific sector involved (e.g.: education; health); and
3. sub-sectoral contextual characteristics (as relevant; e.g.: the drug field within the health sector).

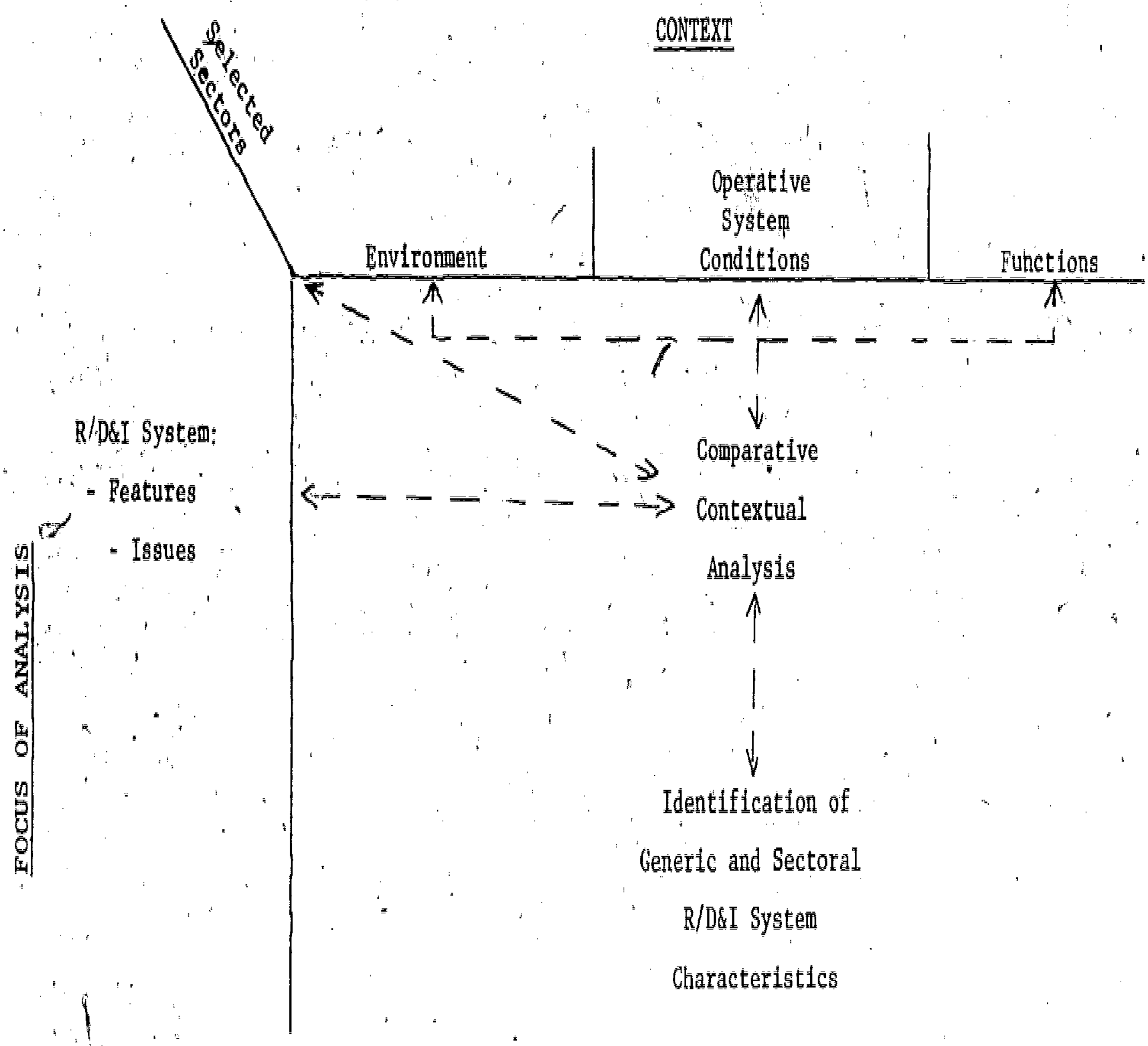

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Figure 3

Framework for Comparative Sectoral Analysis of R/D&I Systems

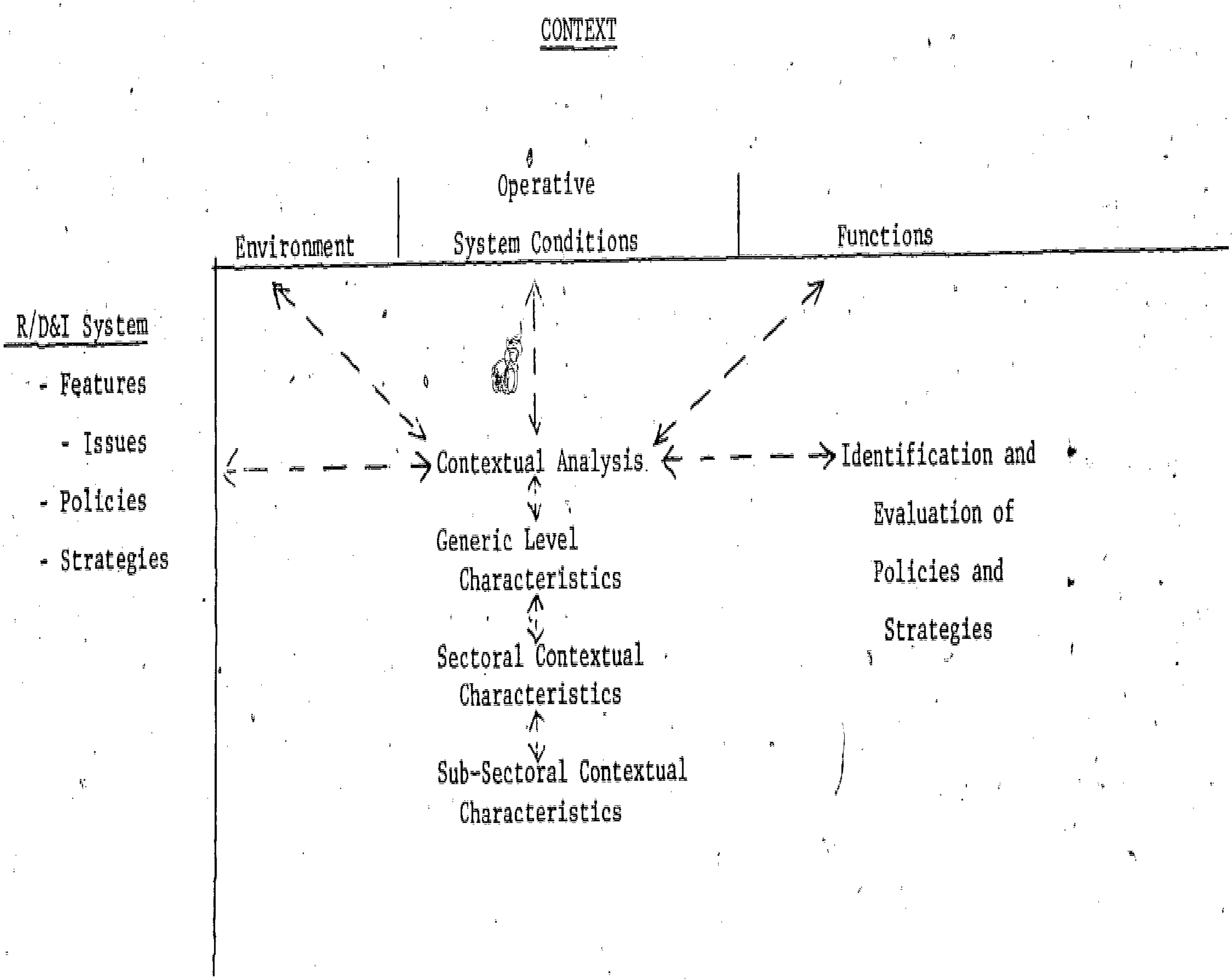

Figure 4

Analytical Framework for Policy Makers:

Identification and Evaluation of Policies and Strategies

In essence, the framework we are now describing is an iterative contextual analysis of one or more selected R/D&I system features, issues, policies or strategies in light of what is known about relevant generic R/D&I characteristics and about the characteristics of the given sector (and, as relevant, of the given sub-sector).

This framework will permit us to compare descriptive findings of system features and issues (the sectoral context) with what we would expect (or would want) to find from the generic perspective. For example, if funding stability and its consequences for basic research is a generic issue for all R/D&I systems, it would be possible to examine the sectoral context in terms of potential for funding stability and to observe whether the outcomes for varying conditions did or did not meet expectation.

Management and policy options could then be generated and action taken that would either deal with the nature of the funding stability or with the procedures being used to cope with the given level of stability. The process is dynamic in that the policy and management actions taken themselves become part of the context-forming process in a feedback mode.

7. Deductive or Inductive Analysis

We should note again at this point that the framework of analysis we have described may be used either deductively or inductively. That is, generic questions can be used as guides or maps to explore real-world conditions (deductive). Alternatively, observations or reports of real-world issues and problems can be traced back to their generic roots (inductive). In either case, the objective for the decision maker is to identify policy options relevant to the observed issues, take any necessary actions, and evaluate the outcome. Thus:

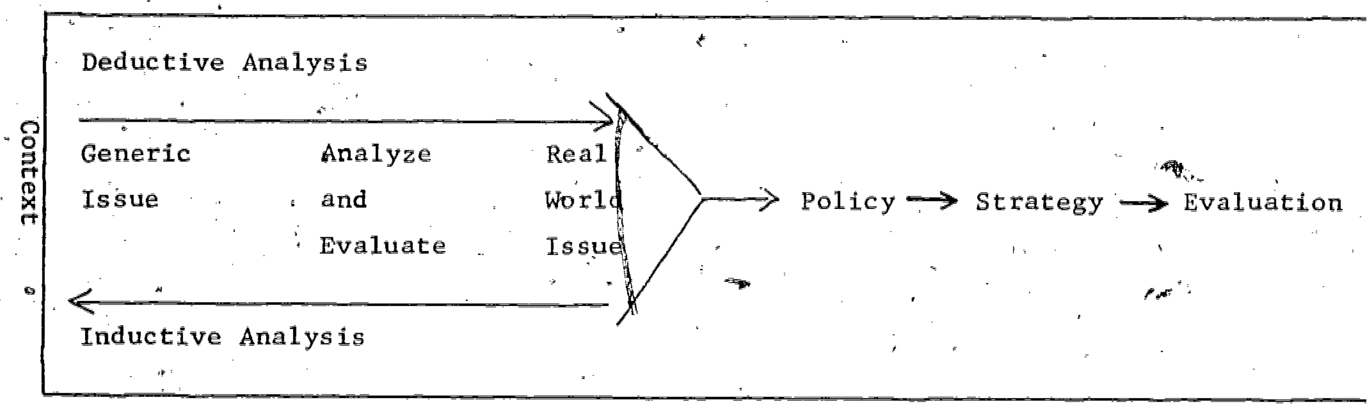

Figure 5

A Deductive/Inductive Framework

V. Conclusion

In this chapter, we have attempted to provide a general understanding of the nature and utilization of a contextual approach to the comparative analysis of R/D&I systems. To further develop an understanding of contextual analysis, we will in Chapter Two expand our discussion of the R/D&I features which (together and interactively) provide the total context in which R/D&I must be understood.

Chapters Three, Four and Five will illustrate how specific sectors may be described and analyzed contexturally.

Chapters Six and Seven will then illustrate how the contextual analytic approach may be utilized to lead one into a detailed focused analysis of key R/D&I issues relative to a specific R/D&I feature. The final chapter will briefly overview the contextual analytic approach. In the Appendix, we will briefly illustrate how we have already begun to address specific, concrete R/D&I issues through this contextual analytical approach.

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CHAPTER TWO

ILLUSTRATIVE DISCUSSION OF THE R/D&I CONTEXTUAL FEATURES

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ILLUSTRATIVE DISCUSSION OF THE R/D&I CONTEXTUAL FEATURES

I. ENVIRONMENT
   A. Political/Legal Environment
   B. Social/Cultural Environment
   C. Economic Environment
   D. Knowledge/Technological Environment

II. HISTORICAL DEVELOPMENT
   A. Development Phases
   B. Critical Events in the Development of the R/D&I System
      1. Institutions Established (or Disestablished)
      2. Legal
      3. Political
      4. Development in the State-of-the-Arts
      5. Funding

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)
   A. Constituent Institutions
   B. Institutional Roles Within the R/D&I System
   C. Characteristics of Institutions
   D. System Configuration (Clustering) of R/D&I Functions
   E. Inter-Institution Linkages
      1. Linkage Characteristics
      2. Linkage Structures & Mechanisms
      3. Boundary Conditions
      4. Linkage Consequences
   F. Characteristics of R/D&I System Structure

IV. GOALS, POLICIES, STRATEGIES
   A. Source
   B. Content
   C. Aspects

V. ADMINISTRATIVE PROCESSES
   A. Responsibilities and Tasks
   B. Administrative Relationships
   C. Administrative System Characteristics
   D. Characteristics of Administrators
   E. Administrative Techniques

VI. PERSONNEL BASE
   A. Types of R/D&I Personnel: Needs, Availability and Sources
   B. Professions and Occupations
   C. Systems Activities Related to the Personnel Base
   D. Characteristics of the System's Personnel

VII. FUNDING
   A. Sources of Funding
   B. Type of Funding
   C. Level and Adequacy of Funding
   D. Stability of Funding
   E. Other Considerations

VIII. INFORMATION FLOW
A. Sources of information
B. Recipients of Information
C. Information Flow Channels
D. Patterns of Information Flow
E. Purposes of Information Flow
F. Networks of Information Flow
G. Utilization of Information
H. Control and Access

IX. INNOVATIONS
A. Requirements for the Innovations
B. Characteristics of the Innovations
C. Impact and Benefits of the Innovations

X. NEED IDENTIFICATION
A. What/How -- Need Identification Processes
B. Where -- Loci of Need Identification Processes
C. Who - - Need Identifiers
D. When - - Timing of Need Identification
E. Need Identification Process Characteristics

XI. GENERATION/RESEARCH
A. Search and Knowledge Synthesis Process Characteristics
B. Research Process Characteristics

XII. DEVELOPMENT
A. The Developers
B. Development Outputs
C. User Focus and Linkage
D. Development State of the Art Linkages
E. Linkages to Production
F. Development Processes

XIII. PRODUCTION
A. Production Processes
B. Characteristics of Production Processes

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION
A. Organizations
B. Product Type
C. User Characteristics
D. Process Characteristics
E. System Level Considerations

XV. ACQUISITION
A. Steps in the Acquisition Process
1. Awareness
2. Search
3. Bidding
4. Testing
5. Evaluation
6. Purchasing
B. Role of Key Personnel in the Acquisition Process
C. Acquisition Process Characteristics

XVI. IMPLEMENTATION/UTILIZATION

A. Implementation Processes
B. Utilization Processes
C. Implementation/Utilization Process Characteristics
D. User Characteristics Influencing Implementation/Utilization
E. Producer Characteristics Influencing Implementation/Utilization
F. Producer/User Relationships Influencing Implmentation/Utilization Processes

XVII. SUPPORT SERVICES

A. Support Service Requirements
B. Linkages to Support Services
C. Support Service Characteristics

XVIII. EVALUATION RESEARCH

A. Two Kinds of Evaluation Research
B. Significant Participants
C. Type of Program or Project
D. Design Methodology and Process

XIX. RESEARCH ON R/D&I

CHAPTER TWO

ILLUSTRATIVE DISCUSSION OF THE R/D&I CONTEXTUAL FEATURES

In the previous chapter, we have briefly discussed the R/D&I contextual features and listed them in Figure 1. In this chapter, our intent is to provide some insight into the contextual analytical framework through an expanded, illustrative discussion of the nature of the features and of feature issues. This will be done primarily in the format of brief descriptive introductory statements and a series of questions about each feature which will illustrate the type and scope of issues involved in a contextual analysis. Hopefully, these questions will suggest to the reader additional questions and issues.

While we make no attempt to be exhaustive in our listing of feature issues (nor to suggest that our method of categorization of issues is the only way the issues could be usefully categorized), we do suggest that a detailed contextual analysis based on these questions would be comprehensive. Neither do we make any attempt here to provide answers to the questions -- both because it is beyond our scope of purpose and because to a large extent the answers will (and must) be context specific. Rather, Chapters Three and Four will illustrate how these questions/issues may be used as a basis or framework for the more specific task of developing a specific contextual analysis for a specific sector. Similarly Chapter Five will provide a brief illustrative cross-sectoral comparative analysis of the various features and feature issues.

Further, in order to keep this chapter illustrative and as brief as possible, we will not in this report cite the literature references relevant to this chapter (we do cite references in other chapters). Rather, we will cite such references in a later volume (for which this report will be an input).

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Some further comments will help guide the reader in understanding and utilizing the contextual analytical framework represented by these features.

First, since there are differences between specific R/D&I sectors, systems and areas of concern, the reader will likely find some of the questions to be of more relevance than others. This is to be expected: different issues will have different meanings in different contexts -- and some issues will be of less importance than others in a given, specific context.

Second, while the issues suggested in this chapter are in effect only a "first cut" analysis (not a detailed analysis), one of the purposes of listing these issues is to help the reader "zero in" on the kind of complex of issues which <u>are</u> worth more detailed analytical effort.

Third, we remind the reader that (as noted in Chapter One) the nature of what constitutes an R/D&I "system" may vary across sectors.

Finally, we will generally here refer to a single R/D&I system or sector. This is done for simplicity, with the assumption that we would usually be focusing primarily on a specific R/D&I system or sector. Of course, in any case where more than one R/D&I system or sector were being considered, the questions provided in this chapter would then be stated in the plural.

I. ENVIRONMENT

Every system exists within and interacts with an environment (which will have many components). What is part of the system's environment and what is part of the system (i.e., the "boundary" question) is not at issue here - - rather, as we have already noted, this depends upon the purposes of discussion or analysis. The issue is: What is the nature and effect of the interaction (actual or potential) between various parts of the R/D&I system and various parts of its environment. From this perspective, we are concerned both with the effects of environment on the R/D&I system and, conversely with the effects of the R/D&I system on its environment. And we are concerned with issues relevant to the differences between open and closed systems.

The concept of environment includes all that may be considered external to the R/D&I system. Thus, the concept of environment is both complex and dynamic, consisting of many parts or elements in interaction not only with various parts of the R/D&I system but with each other.

These various elements of the R/D&I system's environment could be described or classified in many ways. The following is one such classification schema which would have at least a general level of common usage and understanding. We should note here that while the issue questions listed below generally refer (for the sake of simplicity) to the R/D&I system or sector, they may also apply to the institutions within the R/D&I system.

A. Political/Legal Environment

As is true for any organization or system, laws and governmental regulations consitute a significant part of the R/D&I system's environment which can significantly impact the nature of the system. Such laws and regulations may have several sources: at the federal level of particular countries; governmental units within a country (e.g.: state, county, city in the U.S.); international agreements.

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Similarly, the R/D&I system exists in a political environment and is thus subject to political pressures which may differ in terms of sources, impact, intensity, etc. and which may vary across time, in different contextual situations, among R/D&I systems or sectors, etc.

Some important issues could include:

What are the loci of legal processes affecting the R/D&I system and sector (e.g.: level of government; specific governmental agencies; courts; etc.)

What are the existing or potential governmental regulations and policies regarding the type of innovations relevant to the R/D&I system and sector? At what governmental level?

Are regulations and policies of different government levels (or of different agencies at the same governmental level) similar or dissimilar? If dissimilar, what is the effect on the R/D&I system and sector?

In what ways (and with what affects) are such regulations and policies administered?

What are the loci of policital pressures affecting the R/D&I system (e.g.: Congress; governmental agencies; lobbyists; pressure groups; etc.)?

What are the potential (or historical) consequences of such pressures? What might be (or have been) the responses of the system to these pressures?

Are the loci of political pressures focused (i.e., from a specific individual or group) or amorphous (e.g.: societal attitudes)? Are there few or many sources of political pressure?

B. Social/Cultural Environment

An R/D&I system also exists in and is impacted by the socio/cultural environment in which it exists. The socio/cultural environment may be local, regional, national or even international. Different parts of the R/D&I system may have different socio/cultural environments, depending on the geographic location, the R/D&I function involved, etc.; different sectors or different types of innovations may be impacted differentially by the socio/cultural environment; organizations or systems serving in a wide national or international area may encounter several differing socio-cultural environments, etc. Some important issues could include:

What social/cultural norms and values influence knowledge production and knowledge utilization in general and for the R/D&I sector, system, function, or innovation in particular? In what ways and with what effects?

How is R/D&I perceived by the relevant society or culture in terms of status and legitimacy? Is the society or culture open and responsive to innovation and change? If not, what are the barriers which are relevant to the R/D&I system?

What alternative career opportunities (within and outside of the sector) are available to R/D&I system personnel? What relative status do the alternative careers have? What is the general status of careers in R/D&I?

C. Economic Environment

Because an R/D&I system is highly dependent upon the level and stability of its funding, we need to understand the overall economic environment which affects such funding.* Here some important issues could be:

What is the state of the host economy (of a country) in general and for the sector served by the R/D&I system in particular?

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*The funding process itself is discussed as a separate feature later.

What is the development pattern of the host economy (i.e.: rich or poor nation; industrial/non-industrial; mixed or narrow based economy; lesser developed country or developed country)?

What is the level of priority given to R/D&I in the general economy and within the particular sector served by the R/D&I system? Do the levels of priority vary among the R/D&I functions?

What is the overall level of expenditures in the sector served by the R/D&I system?

To what extent is the R/D&I system vulnerable to short term and/or long term fluctuations in the general or sectoral economy? What preparations or responses does the R/D&I system make in relation to economic fluctuations?

Considerations such as the above not only provide insights into how and why an R/D&I system operates as it does, but also suggest policies and strategies relevant to system development and orchestration.

D. Knowledge/Technological Environment

It is obvious that (by definition) an R/D&I system and its institutions are affected by the knowledge/technology which is available. Further it is also important to recognize that R/D&I systems interact with and utilize/adapt the knowledge/technology of other R/D&I systems. (It is for this reason that we include the knowledge/technology base as part of the R/D&I system's environment.) We should note that while the issue questions listed below are usually phrased in terms of the R/D&I system, the questions also apply to the institutions within the R/D&I system.

Some important issues could be:

What is the level of sophistication (state of development) of the knowledge/technology base?

What kinds of knowledge/technology are or are not available?

What factors and processes affect the development, acquisition and use of the knowledge/technology base?

What are the basic disciplines and/or sectors from which the R/D&I system draws its knowledge/technology? What are the mechanisms, barriers, etc. for transfer of knowledge/technology between disciplines, R/D&I sectors, R/D&I systems, R/D&I institutions?

What technologies are generalizable (transferable) across sectors and which are not? Why not? Across which sectors?

What is the state of development of the R/D&I system? How does this affect the R/D&I system's capability to identify, select and use potentially relevant knowledge/technology from other R/D&I systems?

What are the comparative states of development of the knowledge/technology base among the different R/D&I functions? What affect does this have on the overall knowledge production/knowledge utilization flow of innovation (e.g.: if the knowledge/technology of development is significantly more sophisticated than the knowledge/technology base relevant to implementation/utilization)?

How feasible is technological forecasting? To what extent is it done (and how) by the R/D&I system and its institutions?

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II. HISTORICAL DEVELOPMENT

Historical development is an important contextual feature from two perspectives. First, it will be important to know the level of development (maturation) which currently characterizes the R/D&I system. The current level of development will have significant implications for the types of policies, programs and strategies that are relevant.

Second, the past is a significant part of (and thus to a greater or lesser extent, has a determining effect on) the present and the future - - for systems and institutions as well as for individuals. Thus, to understand "where" it appears to be going, can go, or should go, we must have adequate knowledge of its history.

It is necessary to consider the history of the R/D&I system and also to have some understanding of the historical development of the institutions within the system and of the sectoral and societal contexts of which the R/D&I system is a part.

A. Development Phases

Two points must be made here. In the first place, we are here looking at a complex dynamic of historical development from a general, descriptive perspective - - not from either a normative or an "inevitability" perspective. Thus, we do not imply either that all R/D&I systems will inevitably reach each stage or find appropriate forms of development; or that all potential characteristics of a phase will exist for every system; or that historical development is a one-way process. Indeed, if a "mature" system becomes static and out of touch with its environment, it may over time "decline" (and no longer possess the characteristics of a "mature" system) and/or repeat earlier phases of development.

Secondly, the meaning of system maturation must be understood somewhat differently in different sectors and in different contexts. Thus, when compared (for example) with aerospace, even a "mature" R/D&I system in a social service sector such as education will always be somewhat more "messy" in its knowledge base, system linkages, etc., simply because human/social systems have inherently highly value laden contexts, have relatively hard-to-define goals and hard-to measure outcomes, etc. And on the other hand, industrial R/D&I systems may be more closely linked than social service R/D&I systems.

Thus, while the comments and issue questions which follow are of potentially critical importance, we must keep in mind that not all R/D&I systems are or need to be the same - - and that specific stage-of-development issues may apply differently to different R/D&I systems. With the above in mind, let us make the following observations.

Institutions and systems do go through phases of development. The most simplified description of what is a quite complex dynamic would be to say that systems have introductory, transitional, and mature phases of development. The introductory phase is typically characterized by inadequate system linkage, coordination, and overall management and direction; significant "gaps" in the system; undeveloped knowledge/technology and institutional bases. The attention given to the various R/D&I functions is uneven and unbalanced. Emphasis tends to be placed on "localized" rather than on "system" issues and concerns. In the transitional phase, many of the above conditions remain - - but there are more established institutions; some linkages do exist; there is an at least identifiable knowledge/technology base; etc. In the transitional phase, however, members of the system have begun to recognize the above conditions as "system" rather than merely "localized" issues and concerns - - but the system is not yet capable of more than minimal self-orchestration. In the mature stage of development, we find (where needed and appropriate) significantly developed and coherent knowledge/technology/institutional/personnel bases; linkages do exist; there is a balance in the level of development of R/D&I functions; system management structures and processes are operational; the system is more capable of a significant amount of self-orchestration; etc.

Some important issues about the development phase of the R/D&I system could be:

What is the level of development of the R/D&I system, the R/D&I functions, the R/D&I institutions?

Is the development level of an R/D&I system different from the development level of its sector?

Are the development levels of the R/D&I functions within a particular R/D&I system different from the development levels of the R/D&I functions in other R/D&I systems with which it does (or could) interact?

Are the R/D&I functions within an R/D&I system at different levels of development?

How do differences in levels of development impact the interaction between the R/D&I system and its sector, between R/D&I systems, between R/D&I functions within a single system? How do these differences affect the flow of innovation, the possibility of technology transfer, etc.?

To what extent is system-building a critical need of the R/D&I system? For what parts of the R/D&I system?

How well has a balance been maintained among the system's R/D&I functions in terms of proper sequencing within the overall system development process and in terms of most effective utilization of resources? Is there currently a need for staging/phasing policies and strategies in order to insure such a balance?

To what extent has some system-wide agency played a role in orchestrating the system, to fill "gaps", to balance the rate of development among R/D&I functions? Is there currently such a need?

Are system mechanisms established in the early stages of a system's development relevant to the current stage of the system's development? If not, what flexibility does the system have to modify (or even eliminate) these mechanisms?

What are the time/maturation effects on: system operation effectiveness; delineation of issues; establishment of priorities; institutionalization of the R/D&I system; acceptance of the R/D&I system and its outputs within the sector; etc.

B. Critical Events in the Development of the R/D&I System

Thus far, we have looked at historical development from a general broad-brush perspective. It is equally important to know about and understand the impact of the more specific historical events which have been critical in influencing the development of the specific nature or character of an R/D&I system. Such critical events may have impacted the R/D&I system in a variety of ways - - e.g.: influencing the major emphases or foci of the system; increasing or decreasing internal system capabilities; establishing patterns, precedents, priorities, requirements; supporting or blocking system activities or system development; influencing the relative rates of development of the system's R/D&I functions (and thus the "balance" among these functions; etc.).

An examination of critical events should include at least the following areas:

1. Institutions Established (or Disestablished)

When? Private or public? Profit or not-for-profit? Academic or non-academic? For which R/D&I system functions? How has the balance among the various types of institutions been affected?

2. Legal

What laws have significantly affected the development of the R/D&I system? In what ways? Why were these laws passed? At what level of government (federal, state, local)? In what ways have such laws changed over time, and with what effect?

3. Political

What specific events have significantly affected the R/D&I system over time? In what ways? What significant changes have there been in the political context? To the extent the political context has changed over time, what effect has the pattern of change had on the R/D&I system?

4. Development in the State-of-the-Arts

What has been the pattern of significant developments in the state-of-the-arts? Have the developments been relatively sudden or gradual? Major single developments or incremental developments? What effects have these developments had?

5. Funding

What has been the level of funding for the R/D&I system? Stability? What have been the major sources of funding? What have the significant events in funding? What impact have these had on R/D&I?

Critical events in all of these areas may be seen as an "input" to the R/D&I system which have had some significant (though of course not exclusive) effect on determining the idiosyncratic nature and characteristics of the R/D&I system both as it currently exists and as it may exist in the future. We may also ask: Have the critical events been "appropriate" to the state of the R/D&I system's development -- and if not, what has been the effect on the system?

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

An R/D&I system is composed of a variety of institutions which, loosely or coherently, form a network of institutions. Thus, we will want to examine the institutional base from two perspectives. First, we want to look at the institutions themselves: what the constituent institutions are; what are their institutional roles within the R/D&I system; what their characteristics are.

Second, we will want to know how these institutions form a "system"; what is the system configuration of R/D&I functions; how the institutions are linked together; what the characteristics of the system structure are.

A. Constituent Institutions

An R/D&I system involves a variety of institutions which form the institutional base of the system. It will be important to identify these institutions. Here, some important issues could be:

What institutions are involved in the R/D&I system?

Are they: public/private; profit/not-for-profit; federal/state/ local government; universities/industries/professional associations; etc.

B. Institutional Roles Within the R/D&I System

We will want to know what roles the various institutions have within the R/D&I system. Some important issues could be:

To what extent do the institutions specialize in particular R/D&I functions (e.g.: research, dissemination, etc?) Which institutions? Which R/D&I functions (or combinations of R/D&I functions?)

What are the roles of the various institutions in relation to the R/D&I system as a whole, to other institutions of the R/D&I system, to other relevant institutions and systems in the environment of the R/D&I system (e.g.: what is the role of a government agency which is part of the overall R/D&I system?)

Do the institutions serve only (or primarily) the specific sector (e.g.: public schools, NIE, or the federally sponsored R&D labs in the education sector)? Or are they sector-spanning institutions which serve several sectors (e.g.: NSF, IBM, many R&D organizations, book publishers)? What is the level of their commitment to the sector, and why?

C. Characteristics of Institutions

We will also want to examine the characteristics of the institutions of the R/D&I system. Some important issues could be:

What are the internal structures of the institutions (in terms of their configuration, integration, centralization, formalization, articulation/visibility, stability, etc?)

What are their internal processes of decision making, communication, authority/status, cooperation, etc.

What are their sizes, status, resources, experience?

What are their levels of maturation and technological sophistication?

What are their ranges of products, services, etc?

D. System Configuration (Clustering) of R/D&I Functions

As we noted in Chapter One, the various R/D&I functions may be grouped or clustered together in a variety of ways - - and they may be grouped or clustered together in differing structural configurations in or across different institutions within the same R/D&I sector or across differing R/D&I sectors. Some important issues could be:

In what form are the R/D&I functions clustered together (e.g.: linearity, parallelism, looping/contiguous, continuity/gaps, redundancy)?

Which R/D&I functions are clustered together?

What differences in the above are there across institutions within the R/D&I system?

E. Inter-Institution Linkages

The linkages between the various institutions of a system and the linkages of the system to its environment are critical. Thus, some important issues could be:

1. Linkage Characteristics

Are the linkages: strong or weak/ permanent or short term? stable or unstable? direct or via intermediary institutions/ mechanisms/associations?

Are the linkages formal or through informal communication and collaboration?

Are the linkages centralized or diffuse?

What are the system's processes for decision making and communication?

What is the nature of authority and status in the linkage process?

2. Linkage Structures and Mechanisms

What are the existing linkage structures and mechanisms?

How do they work?

Who controls them?

Are there "gaps?"

3. Boundary Conditions

Here, questions would apply both to the "boundaries" of institutions within the system and to the "boundaries" between the system and its environment.

Is the R/D&I system an open system (so that institutions relate easily, collaborate, etc.) or a closed system (so that issues of "turf" and autonomy frequently and strongly arise)?

Are these "boundary conditions" fixed (e.g.: by law; by a strong, emotion-laden history) or variable?

4. Linkage Consequences

Are the existing linkages functional or dysfunctional?

Do they seem to result in coordination, cooperation, conflict, or simply lack of system coordination?

Are there (or have there been) "joint venture" arrangements? Between what institutions? With what results (and why)?

F. Characteristics of R/D&I System Structure

We will want to examine various characteristics of the R/D&I system's structure. Some important issues could be:

What is the stability of these configurations over time? If unstable, why? Have the configurations changed in response to the developmental phases of the R/D&I system, of the R/D&I function(s) involved, or of the particular institutions involved?

Are the configurations appropriate in terms of phases of development, institutional goals, the personnel/financial resources of the institutions, etc?

Are these configurations "visible" (known) to relevant parties within and/or outside the system?

Is there a balance among the R/D&I functions being performed by the system's institutions? Are there gaps? Is there unnecessary redundancy? (Note: redundancy is not "bad" per se.)

Is the structural configuration of R/D&I functions centralized or decentralized and diffused within the R/D&I system? Is it formalized or through informal associations and linkages?

IV. GOALS, POLICIES, STRATEGIES

Goals, policies and strategies are the "action-oriented" aspects of R/D&I and are identified as a separate R/D&I feature for precisely this reason. While the terms may be defined variously, we here mean to be comprehensive in our understandings by thinking of "goals" as statements of what one intends or desires to happen, of "policies" as the general guidelines for the accomplishment of goals, and of "strategies" as the specific methods for accomplishment of goals within the guidelines of policies. In a detailed conceptual analysis, we would be examining goals, policies and strategies at the R/D&I sector, system and institution levels. Further, such goals, policies and strategies would need to be examined from at least three interactive perspectives.

A. Source

There may be a variety of sources for goals, policies and strategies which can affect an R/D&I system and its constituent institutions. Thus, some important issues could be:

What are the sources of goals, policies and strategies which impact the R/D&I system and its institutions?

Are these sources external to the R/D&I sector, internal to the sector, internal to the R/D&I system, and/or specific to an R/D&I function?

What is the organizational or system level of the sources (e.g.: level of government; level within an organization)?

What kinds of institutions are involved (e.g.: public/private; university; profit/not-for-profit; etc)?

What significance can/should be attached to the specific source of a goal, policy or strategy (e.g.: status, legitimacy, sources)?

B. Content

The content of goals, policies and strategies is of obvious significance. Further, the content of goals, policies, strategies is dynamic in the sense that it may vary and change over time, in different contexts, as the knowledge base changes, as sectoral needs change, as R/D&I institutions change, etc. Thus, some important issues could be:

What is the content of goals, policies, strategies? How do they differ across the R/D&I functions?

Are the goals, policies, strategies related to identified needs? Identified by whom?

How are the goals, policies, strategies affected by the differing needs, interests and capabilities of different sources?

What is the intended impact of goals, policies, strategies? What is the "secondary" or "indirect" impact?

Are the various goals, policies and strategies compatible or incompatible in terms of the R/D&I system as a whole and/or in terms of specific R/D&I functions or organizations?

What is the relative importance to the R/D&I system and its institutions of the various goals, policies, strategies?

How do changes in the context (e.g.: emergence or decline of institutions; changes in the knowledge/technology base; etc.) affect goals, policies, strategies (in terms of relevance, feasibility, changes in the goals/policies/strategies themselves, etc.)?

C. Aspects

Given that we know the source and content of relevant goals, policies and strategies, there are still a number of aspects of these that will significantly influence the impact they will have on the R/D&I system. For example:

Scope - - What are the funding requirements and commitments? What R/D&I functions are involved? What institutions, other sectors, other R/D&I systems are involved directly or indirectly? What are the personnel/knowledge/technology requirements?

Time frame - - Is the time frame long or short; realistic or unrealistic?

Feasibility - - Can goals be attained or policies and strategies implemented? What changes would be required?

Flexibility - - Can required changes be made in the R/D&I system? At what cost? With what effects? Under what conditions? By whom? Is the required knowledge/technology available, or can it be developed?

Clarity - - Are the goals, policies, strategies specific and clear, or vague? Are they clear for different relevant audiences? Do different relevant audiences understand them differently?

Stability/continuity - - Are goals, policies, strategies relatively stable over time, or do they change and shift? Over what periods of time? In relation to which sources? With what effects?

Differential perceptions - - Do various relevant audiences have similar or dissimilar perceptions as to the importance, relevance, feasibility, time frames, etc. of the goals, policies, strategies?

Balance - - Are goals, policies and strategies balanced in terms of: relative priorities; sources; the various R/D&I functions and institutions; system and institutional needs related to level of maturation; etc?

Compromises - - To what extent are the various sources willing to make compromises in order to achieve system balances, to orchestrate the system's activities, to fill gaps in the system, etc.? What mechanisms and processes are used to reach such compromises?

Appropriateness/congruence - - Are the goals, policies, strategies appropriate and congruent in relation to: the nature of the function involved; the state of development of the system; the knowledge/technology base; adequacy of personnel/ institutional/financial resources required and available; the social/cultural environment; laws and regulations; etc.

V. ADMINISTRATIVE PROCESSES

Administration (management) is a function of all organizations and systems, and much of the research, literature and experience relative to this function is not unique to R/D&I systems. Nevertheless, we must be aware that the relatively high degree of uncertainty and creativity involved in the process of innovation will impact administrative processes in R/D&I systems. We will, of course, want to focus our analysis on the R/D&I system in terms of describing the existing R/D&I system, in terms of identifying those aspects or characteristics of the administrative processes function which are specific to R/D&I systems, and in terms of determining what administrative technologies can or cannot be transferred from one sector to another.

We should also note here that we include both policy and operational levels of administration/management within our understanding of the administrative processes function.

The literature on administration is quite copious, both in terms of sheer volume and in terms of identifying and analyzing a large number of aspects, characteristics and processes of administration. Thus, analyses will generally need to be selective - - but not meager.

A. Responsibilities and Tasks

There are many responsibilities and tasks which may be part of the administration function. These may be (and are) identified, described and labeled variously, but would at least include the following broad categories:

- identification of goals and objectives
- establishment of policy
- formulation of strategies
- planning and programming
- mobilization and allocation of resources
- design, installation, operation and modification of management systems
- communication
- motivation

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For each of these areas of administrative responsibilities and tasks, some important issues could be:

Who has the responsibility?

Who actually performs what aspects of the required tasks?

What skills are needed?

How and by whom are responsibilities and tasks assigned?

At what level within the organization or in what part of the system are responsibilities and tasks located?

Upon what data are decisions made and actions taken? What are the sources of this data? What degree of reliability and certainty can be ascribed to this data?

B. Administrative Relationships

Administrative relationships involve the organizationally based interactions between the personnel of an organization or system. While administrative relationships are defined in relation to organizational roles, tasks, rules, etc. (and are usually understood to be "formalized"), administrative relationships may vary in terms of clarity and preciseness, commonness of understanding between the parties involved, degree of formalization, etc. Further, attention must be given to the interpersonal/intergroup relationships between the parties involved in an administrative relationship. We do not include here interorganizational relationships per se (though there may be some overlap), as this is part of the institutional base feature.

Some important issues could be:

What is the level of administrative relationships under consideration, (i.e., at international, national, system, institutional, intra-institutional level)?

What type of organization or organizational unit is involved, (e.g.: federal agency, a private business, an academic institution, a regional lab, a committee, a task force, etc.)?

What is the mode of the administrative relationship (e.g.: line-staff, liason, matrix, etc.)?

What is the formal nature of the relationship, (e.g., legal, authority, voluntary, consultative, advisory, etc.)?

What are the interpersonal (intergroup characteristics of the relationship, (e.g.: collaboration, competitive, conflict charismatic, trusting/suspicious, etc.)?

C. Administrative System Characteristics

We may examine the administration function in terms of its characteristics as a system itself. Some important issue areas could be:

To what extent is the administrative system centralized or decentralized? Is this appropriate or inappropriate in terms of the level of system maturation, the nature of the tasks involved, the nature and needs of specific R/D&I functions, etc.?

To what extent is the administrative system formalized by rules, regulations, policies, procedure manuals, etc.?

Is the administrative system relatively adaptible or inflexible? What parts of the administrative system? Under what conditions would adaptibility be most needed? What costs would be involved in changing the administrative system (financial costs, system disruption, loss of personnel, etc.)?

In what ways and to what extent is the administrative system organized by/dependent upon specializations (in terms of: types of specialization needed within the administrative system; impact upon the structure of the system; specialized managerial skills required)? What types of specializations? In what ways are such specializations integrated with or disaggregated from each other? What level of technical sophistication is required with regard to the different specializations?

In what ways and to what extent is the administrative system based upon/affected by formal rules, procedures, etc.?

To what extent are administrative roles, relations, policies, selection of personnel, etc. politicized (i.e. affected by political dyanics)? What are the sources of political dynamics (e.g.: internal to the system; pressure groups; governmental)? How pervasive are the political dynamics within the system? In reference to what issues?

D. Characteristics of Adminstrators

The individuals who are the administrators bring certain personal characteristics to the process of administration. Among those characteristics which might be of particular significance to R/D&I could be the following: entrepeneurship, risk propensity, innovativeness, receptivity to change. Some important issues here could be:

To what extent do the administrators of the R/D&I system reflect these characteristics? In which organizations?

Does the impact of and/or need for these characteristics differ according to R/D&I functions, different organizations within the system, different levels within organizations, different levels of system maturation, type of innovation, etc.?

What is the impact of and/or need for other personal characteristics of R/D&I system administrators (e.g.: leadership style; orchestration, collaboration, political skills)? Under what conditions? In relation to what parts of the system?

E. Administrative Techniques

Various administrative techniques and methods are used to perform the administrative processes function. These may differ between sectors, between organizations, according to tasks involved, etc. Some important issues could be:

What administrative techniques are commonly used in the R/D&I system? How do these compare with or differ from those used in other R/D&I systems and sectors?

What administrative techniques are most relevant in terms of the level of R/D&I system's maturation, the different R/D&I functions, the nature of the tasks involved, etc.?

What are the conditions which help or hinder the applicability/usability of administrative techniques across different sectors? Is a particular technique which is useful in one sector also useful in another sector? If not, why not?

What are the patterns, mechanisms, dimensions of transfer and diffusion of administrative techniques from one R/D&I system to another?

VI. PERSONNEL BASE

It is obvious that the personnel base is a critical aspect of any organization or system. This is especially true in any R/D&I system which, by definition, involves the human activity of creativity. It is also clear that the personnel base feature is a highly complex feature -- one which can and must be analyzed from a variety of interative perspectives. We will here suggest and illustrate some of these perspectives.

In broad terms, we may see the personnel base both as a resource input to the R/D&I system and as an output of the system. Thus, from the resource input perspective, we will want to know how the personnel base impacts the system in terms of: the skills, perspectives, experience, etc. which they bring to the system; whether or not personnel needed by the system are available or not; the extent to which individual goals and objectives are similar or dissimilar, compatible or incompatible with goals and objectives of an R/D&I system or organization; etc.

On the other hand, the personnel of an R/D&I system may be seen as an output of the system in the sense that the personnel do change as a result of training they receive; their socialization into the system and its organizations; the learning which occurs through experience; etc.

A. Types of R/D&I Personnel: Needs, Availability and Sources

One of the first things we would want to know about an R/D&I system's personnel base is the types of personnel (and personnel "expertise") which are needed by the system. Some important issues could be:

What types of personnel are currently needed (e.g.: administrative/ technical; scientists/engineers/machine operators; skilled/ semi-skilled/unskilled; etc.)?

What types of personnel are needed in terms of the specific nature/needs/requirements of: the different R/D&I functions; the particular sector; the type of technology involved; the particular organization (or type of organization -- e.g.: government agency, private industry, university, R&D organization, user organization, etc.); governmental requirements (e.g.: age, sex, race antidiscrimination laws); etc.?

What specializations are needed? What mix, mass and balance of skills and specializations are needed?

What time lines are involved either for training personnel or for creating sources of personnel (e.g.: how long does it take to train a researcher, a disseminator, a technical specialist, etc.; how long does it take to create programs and institutions to provide such training)?

What has been the historical pattern of the system's personnel needs?

What are the projections for future needs?

In what ways are current and future needs likely to be effected by such factors as: technological changes; changes in the economy; funding patterns; needs of the sector; marketplace demands and requirements; turnover rates (and what are the causes for the turnover rate); changing ages of current personnel over time; retirement rates; existing or anticipated laws; obsolenscence; aging, etc.

We would also want to know about the <u>availability</u> and <u>sources</u> of needed R/D&I system personnel. Some important issues could be:

Are the needed personnel available, in short supply, or in oversupply?

What has been the historical pattern of the availability of needed personnel?

What are the projections for future availability of needed personnel?

What is the impact (short term and long term) on the system of the level of availability of needed personnel?

In what ways will availability of needed personnel be impacted by such factors as: the ability of the R/D&I system to attract and retain needed personnel; funding patterns; technological changes; retirement rates; governmental regulations?

What are the existing sources for needed personnel (e.g.: universities and colleges; technical institutions; internal organizational training programs; second career personnel; etc.)? Do these sources exist within or are they external to the sector? Are they adequate in terms of either number, quality or particular types of personnel needed? If not, can the system provide such sources?

What environmental factors affect the personnel base (e.g.: population growth rates, laws and regulations, societal norms and values, state of the economy, etc.)?

B. Professions and Occupations

In addition to looking at the personnel base from the general perspective of the R/D&I system, we will need to examine as separate systems those specific professions and occupations which are relevant to the R/D&I system. Some important issues could be:

To what extent are the various professions and occupations specific to the sector in which the R/D&I system exists (e.g.: the teaching profession of the education sector)? To what extent are they sector spanning (e.g.: computer technicians)? To what extent do they have both sector spanning and sector specific characteristics (e.g.: researchers within a specific discipline, whose research skills/methodologies may be at least partially sector spanning but who are socialized in/committed to a specific sector)?

Are there organized associations related to the particular occupations and professions? What status and power do they have? Are their goals and values compatible or incompatible with the goals and values of the R/D&I sector, system and/or organizations? What is the level of commitment of these associations to a particular R/D&I sector or system?

What are the entrance requirements/standards/regulations for these professions and occupations? Who sets them? Who implements and monitors them? Who evaluates potential personnel? What is the impact of these requirements/standards/regulations on the availability of needed personnel?

What are the knowledge life cycles for these professions and occupations?

What career paths are provided within the R/D&I system? Are there alternative career paths within the system (e.g.: between organizations, between R/D&I functions)? Are there alternative career paths available in other sectors or R/D&I systems? What are the mobility patterns within the R/D&I system, between professions and occupations, between sectors?

What are the status systems within the R/D&I system?

C. <u>System Activities Related to the Personnel Base</u>

It will be important to know how the R/D&I system responds to its personnel needs. Obviously, here our concerns will overlap a portion of the administrative processes function.

Here, some important issues could be:

What is the nature, extent and adequacy of monitoring, forecasting and planning for the system's personnel needs?

What is the nature of the system's incentive systems (e.g.: financial, position, status, promotion; formal/informal; etc.)? Are they relevant to the needs and motivations of personnel? How do they differ across R/D&I functions and institutions?

What are the processes and criteria for recruitment and selection of personnel?

What is the nature of the socialization process for system personnel?

What is the type, extent and methodologies of training and development?

Does the system deal with personnel obsolescence through replacement or training?

Who sets, implements, monitors R/D&I system requirements in relation to tasks of the system, performance requirements and standards, etc.? Is this done internally within the system or is this imposed externally (e.g.: by governmental laws, regulations, agencies)? How are these "enforced"?

How is information about the personnel base disseminated/diffused throughout the R/D&I system? By whom? Who uses such information? Are there significant "gaps"?

D. Characteristics of the System's Personnel

Thus far, we have focused on the personnel base feature in terms of the R/D&I system. It will also be important to have some knowledge about the personnel themselves. Here some of the major issues could be:

What are their levels of commitment to the sector, the R/D&I system and particular organizations?

What is the nature of their motivation (e.g.: financial, status, responsibility, creativity, etc.)? Are these motivations "matched" with the incentives provided by the system?

What are the values of system personnel?

What are the goals and objectives of system personnel? Are these compatible or in conflict with goals and objectives of the R/D&I system, functions and institutions?

What perspectives, experiences, biases, etc. do the personnel bring to the R/D&I system (in terms of their background)?

VII. FUNDING

Funding is a feature which, at least at a minimum level of sophistication, is easily recognizable as being significant to the process of innovation. Indeed, in our analysis of other features, we have referred repeatedly to issues of cost. ~~However, while analysis of funding must obviously inlcude considerations~~ of cost, analysis of funding must also include consideration of sources of funding, availability/obtainability of funding, the process and constraints involved in obtaining funding; the stability of funding, and so forth. In a word, "cost" focuses basically on <u>amounts</u>; "funding" focuses more broadly to include processes and dynamics.

A. Sources of Funding

At the simplest level, it will be important to know where funds for R/D&I come from. Some important issues could be:

What are the major sources of R/D&I funding: government sources (and from what level of government: local, state, federal, even governments of other countries); foundations; private organizations not involved in the R/D&I system or sector; private organizations which are part of the R/D&I system or sector; investment organizations; etc.?

In what ways are the sources subject to such dynamics as the waxing and waning of national issues; political shifts; the general economic climate; degree of risk involved? Do such dynamics affect the various funding sources similarly or differentially?

What is the level of commitment of the funding source to R/D&I? To a particular area of concern? To a particular innovation? To a particular R/D&I sector, system or institution?

What aspects of R/D&I are of major or peripheral concern to the funding source?

What is the financial condition of the funding source? How much of its funds are available for R/D&I?

Is funding for programs/projects stimulated by field-iniated proposals or by funding agency plans/programs/requests-for-proposals?

What kinds of return on investment does the funding source expect (e.g.: financial, new products, system building)? Within what time frames?

What are the policies of the funding source with respect to R/D&I? With respect to a specific R/D&I sector, system or institution?

B. Type of Funding

Funding from the various sources may be of several types. The issue here is not whether one type of funding is inherently "better" or "worse". Rather, it is important to recognize the implications for R/D&I that accompany different types of funding. Further, it is important that the type of funding be appropriate to the need -- and the need tends to differ across the various R/D&I functions. For example, when system building is the major R/D&I

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system need, a federal agency may need the flexibility to select a few high quality institutions (or to create institutions) rather than scattering its funds among many institutions and thereby abdicating any responsibility for "quality control". In such a situation, grants would be a more appropriate type of funding than competitive bidding.

Some important issues could be:

What types of funding are available from the various funding sources (e.g.: appropriations from legislative bodies to other government agencies; grants; contracts; sales of products and services; etc.)?

Are funds available on a "sole source" or only on a competitive bidding basis?

Are funds provided on a fixed amount or a cost-plus basis?

How do the types of funding differ in terms of the amount of discretion and flexibility the recipient may exercise in the use of funds?

Is the type of funding available appropriate to the needs of the R/D&I system, function or institution? To the type of program or project being funded?

On what basis is funding provided (e.g.: historical basis; percent of income/sales; etc.)?

C. Level and Adequacy of Funding

The level and adequacy of funding is clearly important for R/D&I. Some important issues could be:

What is the level of funding with respect to the sector, the R/D&I system, each of the R/D&I functions, specific areas of R/D&I concern (e.g.: the aerospace/moon landing concern of the 60s; filling "gaps" in the dissemination system), specific programs/projects, and as relevant, specific institutions?

Is the level of funding adequate to meet a particular R/D&I system need or the requirements of a particular innovation?

Is the level of funding balanced across the R/D&I functions in terms of the respective levels of funding needs of the R/D&I functions and in terms of the total flow of innovation from knowledge production to knowledge utilization?

Is the level of funding adequate to meet the expectations of the funders? (This question should also be phrased in terms of whether or not the expectations of funders are realistic.)

What can/should be done within the limitations of the existing, given level of funding?

Are there maximum levels beyond which funding cannot be used effectively? (For example, the amount of funding that can be effectively utilized within the basic research function will be limited by the extent of the existing personnel/institutional bases.)

Are there minimum levels of funding needed in terms of (for example) the costs in a particular area of innovation, the need to maintain (but not expand) the existing personnel/institutional bases, etc.?

What factors must be considered in order to determine the level of funding needed (e.g.: the capital, operating, personnel and maintenance costs involved during the various stages of the R/D&I process; the nature of the innovation involved; whether or not system building is involved; etc.)?

D. Stability of Funding

In R/D&I, stability of funding can be critical. Some important issues could be:

Has funding tended to be stable or unstable?

What has been or would be the short and long term impact of funding instability in terms of: R/D&I system stability and capability; the personnel and institutional bases of the R/D&I system; short and long term return on investment; sunk costs; whether or not there will be innovation "outcomes" or "results"; the adequacy of innovation outcomes/results; etc.?

Over what period (length) of time is funding stability needed?

Is there a range of funding levels within which funding may fluctuate without severe short or long term impact? What is this range?

Do funders tend to "pull the R/D&I system up by its roots" periodically? Does this differ across funding sources?

Do these considerations vary across the R/D&I functions; across the institutions of the system; in terms of the relative state of development (maturation) of the R/D&I system, functions, institutions? In what ways?

E. Other Considerations

What factors influence whether funding will be provided for R/D&I and how it can be used (e.g.: laws and regulations; the degree of risk involved; the perceived importance or urgency; differences about return on investment criteria; etc.)?

What is the pattern of funding (i.e.: what R/D&I functions, what institutions, what innovations or areas of concern are funded)?

To what extent have funding patterns tended to "shape" the R/D&I system in terms of which issues/concerns are emphasized or neglected; which R/D&I functions are developed or neglected; the focus, character and strength of R/D&I institutions; etc.?

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VIII. INFORMATION FLOW

In a manner similar to the funding feature, information flow is a feature that "runs through" all aspects of R/D&I. Again, however, it is of such significance that it warrants consideration as a separate feature. We will want to analyze information flow both within the R/D&I system and between the R/D&I system and its environment, as well as within and between the institutions of the R/D&I system.

There is obviously a considerable body of literature dealing with communication, information flow, etc. Thus, we will here simply highlight the types of issues that would be relevant for research, analysis, policies, or strategies.

A. Sources of information

There may be a variety of sources of information for an R/D&I system, and these sources may differ in significant ways. Some important issues could be:

Who or what are the sources of information within and external to the R/D&I system? To the institutions in the R/D&I system?

Are these sources: individual persons and institutions (e.g.: researchers or research organizations; policy makers or policy making agencies; individual or organizational users; etc.); organized information storehouses (e.g.: clearinghouses; libraries; data banks such as ERIC in the education sector; etc.); various types of literature (e.g.: journals; books; records and documents; newsletters; etc.); governmental (federal, state, local or private; related to a specific R/D&I function, or to a particular discipline, or to some institution within the R/D&I system; etc.)?

Are there several types of sources containing similar information (e.g.: a researcher whose article is printed in a journal, which is then stored in a data bank and summarized in a newsletter)?

In what ways does the nature of the sources affect the potential availability of needed information? The potential validity and relevance of the information? In what ways might the potential biases and limitations of perspectives of the sources affect the information they provide?

B. Recipients of Information

We will also want to know who are and/or should be the recipients of what information. Some important issues could be:

Who should be receiving information? What information?

Who does receive information? Do they need the information? Why are they receiving the information? Are they appropriate recipients of the information? Is there some needed information they are not receiving?

Who is not receiving needed information? Why not?

C. Information Flow Channels

In order for information to get from the sources to the recipients, there must be channels for information flow. Some important issues could be:

What channels exist?

Are the channels formal (e.g.: newsletters; dissemination organizations; journals; papers presented at professional meetings; formalized interorganizational and intraorganizational channels and procedures for communication; etc.) or informal (at meetings; by telephone as the occasion arises; invisible colleges; etc.)?

Are the channels appropriate? (Do they connect the right sources with the right recipients)?

Are the channels adequate? (Are there gaps? Can the channels "carry" enough information? Do the channels "distort" the information? If so, in what ways? Do the channels "screen" or synthesize information?)

Are the channels used? (If not, why not? Are they designed so that recipients can assess them? Are they known to potential users?)

D. Patterns of Information Flow

We will need to ascertain the patterns of information flow in order to determine both the nature and adequacy of information flow. Some important issues could be:

What are the primary patterns of information flow in terms of who communicates with whom? Is the information flow unidirectional? Two-way but between isolated sets of senders/receivers? Multidirectional among a variety of senders and receivers?

What sources of information and channels of information flow are or are not used?

What methodologies and techniques are most used? To what extent does the information flow tend to ~~be~~ formal or informal?

How and by whom is the information flow process initiated? (Do users contact producers? Or do producers contact users? Etc.) Who seeks information and who does not? Why?

E. Purposes of Information Flow

Communication is a purposeful act. The purposes may vary, may be different between sender and recipient, may be explicit, implicit or "hidden". Thus, some important issues could be:

What purposes do the various senders and recipients have for sending/~~seeking/~~ receiving information? How do the purposes of the senders and receivers differ? What perceptions do senders and receivers have about the purposes of each other?

Does the information flow accomplish the purposes of senders and receivers? If not, why not?

From what frames of references is information sent and received? (For example, information about an identified need may be interpreted differently by a user and a researcher.)

F. Networks of Information Flow

The discussion thus far has implied but not specifically examined information flow from the perspective of networks of communication or information flow. Such networks may be formalized or may be informal, centralized or diffuse, separated from or integrated with each other. Here the key issues will be:

Where, to what extent and by whom are such networks needed?

To what extent do such networks exist?

In what ways are the networks connected with each other?

What networks are external but relevant to the R/D&I system?

What impact does the existence or lack of such networks have on the R/D&I system?

In what ways are the networks effective or ineffective?

Who performs the various information processing roles within the networks (e.g.: the role of "gatekeeper")?

G. Utilization of Information

When information flow occurs, there are expectations that information will be used and about how the information will be used. Here some important issues could be:

What expectations do senders and receivers have about how information will be used? Are the expectations similar or dissimilar? Compatible or incompatible? If dissimilar, or incompatible, why? What is the effect or impact of there being different understandings?

How is the information actually used? Or is it used? If not, why not?

H. Control and Access

It will be important to know who controls the information flow and how, why and with what effects. The issue of control is not simply one of authority or position, but also is a matter of the types of blockages that effectively control (in the sense of limiting) information flow. It will also be important to know how information is stored and accessed.

Some important issues could be:

Who determines what information will be sent or received; by whom and to whom; when; and what channels and methodologies can/will be used?

Is information flow open, or is it limited by laws, regulations, political considerations, cost, suspicion, lack of awareness by senders of the need a recipient has (or, vice versa, lack of awareness by a recipient that information exists, or what is the source for information, or what channels to use)?

How is information stored and accessed/retrieved? Is information storage/retrieval automated?

Who determines: what information will be stored; how it will be stored; what the retrieval mechanisms/processes will be; who will have access to information?

IX. INNOVATIONS

All of the contextual features we have discussed thus far have assumed the existence of some innovation(s) -- and some understanding of the innovation(s) involved must indeed be incorporated in the discussion of any of the contextual features. However, this very centrality of the innovations themselves warrants considering "innovations" as a separate feature to insure that adequate attention is given during any analysis. Depending on the type and purpose of the specific analysis, the focus may range from consideration of a specific innovation to the broad range of innovations relevant to a particular R/D&I system or sector.

It is also important that we not narrowly limit our concept of what is an innovation. An innovation may be a new product, a new process/methodology/technique, a new concept/theory, new information, etc. The innovation may be related to any R/D&I function or set of R/D&I functions; may involve a single item or a set of items.

The analysis of the innovations feature would include at least three general types of considerations: requirements for the innovations; characteristics of the innovations; impact and benefits of the innovations. Naturally, these overlap to some extent.

A. Requirements for the Innovations

It will be important to know what requirements the innovations must meet and what requirements the innovation itself imposes on the various elements and functions of the R/D&I system. Some important issues could be:

Need identification -- What needs would the innovation meet? Whose needs? How were the needs identified? By whom?

Level and scale of R&D effort -- What scale of costs are involved? What level of complexity and sophistication of technologies is involved? How many and what type of personnel and institutions are involved? What length of time is required?

System management -- What impact does the innovation have on the management of the R/D&I system in terms of coordination/orchestration/communication efforts; nature/amount/type of involvement with organizations external to the R/D&I system and sector?

State of the arts -- What state of the arts of relevant technologies is required by the innovation? What is the current state of the arts, and is it adequate or not?

User requirements -- What do users expect from the innovation? How must the innovation be developed and produced in order for it to be compatible with the user's system and capabilities? (Or, alternatively, what changes would be required within the user system?)

Constraints -- What governmental laws and regulations impose requirements on the development, production, dissemination, utilization of the innovation? What requirements? At what level of government? What requirements are imposed by other organizations (e.g.: professional associations; the participating R/D&I institutions)? What social/societal constraints exist and how would they impact the innovation at <u>any</u> stage of the knowledge production/knowledge utilization process? Are the required resources available or obtainable?

Integration -- With what other technologies or aspects of the R/D&I system must the innovation be integrated or coordinated? What modifications in the existing R/D&I system or specific technologies/facilities must be made for the innovation to be utilized? What other R/D&I

system technologies and facilities must be "in place" before the innovation can be developed, produced, disseminated, utilized?

B. Characteristics of the Innovations

We will also want to examine innovations in terms of their various characteristics. Some important issues could be:

Life cycle -- How long will the innovation "last" before it must be "replaced"? How quickly is the innovation likely to become obsolete? Is there an "after-market"? Are there legal/social factors which could limit the "life" of the innovation?

Costs -- What are the cumulative costs (i.e., to develop, produce, disseminate, acquire, operate, maintain, provide support services, replace, etc.)? Are the costs spread or concentrated in terms of: R/D&I functions; particular organizations?

Testability -- Can the innovation be tested? With what degree of certainty? At what point in its development, production, implementation? By whom can it be tested?

Usage: specialized or generalized -- Is the innovation one which can only be used by a few people or institutions (because of skills or facilities required; costs; limited interest in using the innovation; applicability only to a limited type of situation)? Or can the innovation be used by many people in a wide variety of settings? Is the innovation germaine only to a single sector? Can the innovation be modified for more widespread usage?

Type -- Is the innovation a "hardware" item, "software" item, a process, etc.?

Congruency -- How well does the innovation fit into existing processes, technologies, facilities, etc.?

Complexity -- Is the innovation relatively simple or complex? What level of complexity is involved in implementation/utilization and implementation/utilization support services?

Quality -- What level of quality is needed? Is the level of quality requirement imposed by the nature of the innovation itself, by users, by governmental laws/regulations, by safety considerations, etc.?

Safety -- What are the relevant safety considerations? How do they effect the innovation itself or the processes of developing/producing/utilizing the innovation?

Reliability -- What is the range of the reliability of the innovation? How reliable must it be?

C. Impact and Benefits of the Innovations

Who benefits from/is impacted by the innovation (users, personnel, environment, etc.)?

What is the nature of the benefits and/or the impact?

Are there negative "side effects"? What are they? Who or what aspect of the R/D&I system is negatively affected? Can the negative effects be controlled? Are they "acceptable"?

Are the benefits short term or long term? How quickly and for what continuing period of time will the innovation have impact? Does the time frame for benefits/impact differ relative to different R/D&I functions, different institutions, different R/D&I system needs and issues?

X. NEED IDENTIFICATION

Need identification is an R/D&I function which is critical to any R/D&I system or function. Thus, while there is a certain logic in considering it as the "first" R/D&I function, it is very important to note that need identification may be done in a variety of ways (e.g.: market research; formal or informal user feedback; etc.); may be done by a variety of persons or institutions (e.g.: users, producers, disseminators, etc.); and may be done at any stage of the R/D&I process (i.e., during the performance of any R/D&I function - - e.g.: during research, development, production, utilization, etc.). Thus, the key questions are: What/how? Where? Who? When? Additionally, we will want to know something about the characteristics of the need identification process.

A. What/How - - Need Identification Processes

What are the initial need identification mechanisms?

What need identification methodologies are available? Utilized? Why and with what results? Are they appropriate? Why are some methodologies not utilized?

What needs can be identified in terms of gaps in the knowledge/technology base or in the personnel or institutional bases?

What are the screening procedures?

How are needs communicated (so that they lead to potential innovations)? From whom and to whom?

How are "needs" translated into "solution requirements"?

How are the various need identification processes coordinated, orchestrated, managed?

How does the system coordinate/mediate/integrate differing perceptions of "needs" (e.g.: basic researchers tend to define "needs" differently than do users)?

B. Where - - Loci of Need Identification Processes

Are the need identification processes primarily located within a relatively few of the R/D&I system's institutions, throughout the overall R/D&I system itself, throughout the sector, or outside of the sector? Or is need identification done at all these levels?

C. Who - - Need Identifiers

What institutions are the primary need identifiers? Why?

Within these institutions, what organizational units or positions are the primary need identifiers?

What are the characteristics of the organizations and the personnel who are the primary need identifiers?

D. When - - Timing of Need Identification

Is need identification done at all stages of the R/D&I process?

Is need identification an ongoing, iterative process within the R/D&I system - - or does it tend to be "one-time" and/or "one-way"?

Does the system attempt to project/predict probable needs "down the road" or respond only to the "immediate", currently "pressing" needs?

E. Need Identification Process Characteristics

To what extent are the need identification processes formalized or informal? Centralized or diffuse?

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Are the need identification processes responsive to user demands? Do the processes attempt to create user awareness of needs?

Do the need identification processes most resemble open or closed systems?

Have need identification processes been stable or unstable over time in terms of the institutions, personnel, mechanisms/methodologies involved?

Does the R/D&I system differentiate between the needs relevant to different R/D&I functions, the R/D&I system per se, and the sector served by the R/D&I system?

XI. GENERATION/RESEARCH

Before looking at the types of issues or concerns involved in the generation/research function, we need to set a framework for our discussion. First, our concern here is with what may be called "disciplined inquiry" (though we do not deny the possibility that new knowledge may result by some "un-disciplined" process). Second, we use the double term "generation/research" to indicate that "disciplined inquiry" is not necessarily limited to "researchers doing formal research in a formal research setting". Thus, while our discussion below <u>will</u> focus primarily on formal, organized research, it will be important to know where/how/by whom new knowledge is being produced outside of the formal research setting. Third, we have deliberately avoided setting up a detailed "typology" for the generation/research function because relevant typologies appear to be context-specific. We do find, however, some usefulness in thinking of generation/research in terms of three general types of processes:

1. search (i.e., determining what knowledge <u>already</u> exists);

2. generation/research per se (i.e., the <u>creation</u> of new knowledge);

3. knowledge synthesis (i.e., the <u>re-combination</u> of knowledge into new forms -- which could be considered a particular type of new-knowledge production).

Further, we need to examine the differences between what are commonly called basic and applied research. While many of the issue questions listed below will be relevant to evaluation research, we are treating evaluation research as a separate R/D&I function.

With the above in mind, the following would be issues relevant to the generation/research function.

A. Search and Knowledge Synthesis Process Characteristics

Since the generation/research function is focused on the creation of new knowledge and on extending the existing limits of the state-of-the-art, there is a premium on avoiding "reinvention" - - i.e., on doing what has already been done. (Such "reinvention" should not be confused with "repetition" done for purposes of verification or with the rediscovery of knowledge which is difficult or costly to access.) Thus, some important search issues could be:

What is the available knowledge base?

What are the relevant basic disciplines, and how is the R/D&I system's knowledge base "tied into" these disciplines?

What are the information sources, channels of communication and retrieval mechanisms available for use in the search process? How adequate are they? Which ones are used or not used? Who uses them and who does not?

Since knowledge synthesis is the re-combination of existing knowledge, we would be asking these same questions in relation to knowledge synthesis.

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B. Research Process Characteristics

In order to understand the research function within an R/D&I system, we will want to know about:

What relative priorities are given to basic research (the search for knowledge "for its own sake") or applied research (the search for knowledge relevant to a specific issue or problem)?

Is research being done by individuals or by teams; within individual institutions or in cross-institutional settings; etc.?

What kinds of institutions are involved: public/private; profit/not-for-profit; university/industry/R&D organizations/government; etc.? Where are the "centers of excellence"?

What methodologies tend to be used? What methodologies are the most valid, reliable and feasible with respect to the type of innovation and the sector involved?

Where, how and by whom is "disciplined inquiry" occurring outside of formal research settings? With what impact on R/D&I?

Is the research done within a single discipline, or is it multidisciplinary?

What is the level of maturation of the knowledge base and of the research function in a specific R/D&I system?

What competitive dynamics and patterns are involved in the research function (e.g.: status; proprietary rights)? Involving what researchers or research organizations?

Who controls decisions concerning funding of research; setting of research priorities? What is the role of users in the setting of research priorities?

What stability of funding, institutions, personnel is needed? Does this differ across R/D&I sectors or in terms of particular types of innovation? What has been the pattern of such stability? What level of stability can be projected for the future?

What is the rate at which the research function can be built up or expanded?

What are the linkages between basic and applied research within the R/D&I system? Between researchers? Between research organizations? Between disciplines? Between R/D&I systems? Are there gaps? Are existing linkages used? If not, why not? By whom?

What differences of perspectives are there between funders and researchers? What effect does this have on the research function?

With respect to applied research, what is the effect on the dual foci of "research" and "application", and of potential conflicts between "desirability" and "feasibility"?

How do the above issues differ between basic and applied research?

XII. DEVELOPMENT

The development function is that part of knowledge production which takes existing knowledge and transforms it into a form or format which can be utilized by users. Development is often understood as beginning where research stops and ending when the development output is ready for production. In practice linkages to the research function may be weak, and there may or may not be a clear separation of the development and production functions.

A. The Developers

In a practical sense, development may be done by a variety of persons or organizations -- including users as well as persons trained in development who work in formal development organizations or organizational settings. Who the developers are may impact the nature of the development process and the output of development. Thus, some key issues could be:

- Is development being done by specialized development or R&D organizations, by a development department of an organization, or by users?

- What organizations are doing development? Are they: private or public; profit or not-for-profit; large scale or small scale; sector-specific or sector-spanning? What is their commitment to the sector?

- What kinds and what levels of skills and technical sophistication do the developers need to have in relation to particular types of products (development outputs) being developed? What kinds and what levels of technical sophistication do the various developers currently have?

- What is the range or mix of development outputs on which the development organization works?

- To what external influences are the developers most vulnerable (e.g.: high dependence on government funding in general or in relation to a particular set of governmental agencies; fluctuations in priorities given to their particular areas of developmental concerns; etc.)? Are the developers flexible/adaptable in terms of their areas of focus, the clients whom they serve, their mix of technological skills, etc.?

- Do the developers provide support services to producers? To users? What kinds of support services?

B. Development Outputs

While the outputs of development are probably most commonly thought of in terms of "products", it is important to realize that development may result in a number of different types of outcomes (e.g.: programs, processes, models, strategies, approaches, etc., as well as the narrower range of outputs we typically think of as "products"). Some important issues could be:

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Is the intended development output simple or complex; large scale or small scale; expensive or inexpensive? What mix of technological skills is required?

What are the implications of the nature of the product on: the nature of the development process required; the type, mix and number of personnel required; the feasibility of pilot testing, evaluation?

What support materials (e.g.: instructional manuals) must be developed? What support services (e.g.: maintenance) will have to be provided?

At what point is the development output ready for initial field testing? At what point has the development output been sufficiently tested to permit production, dissemination and utilization?

C. User Focus and Linkage

The emphasis or focus of development is the intended or potential user. Development, then, involves a process of converting knowledge into user-ready outputs (with at most some minimal fitting and tailoring) that can then be produced and distributed/marketed. This, in turn, clearly implies that linkages with the user are important. Thus, some important issues could be:

What are the linkages between developers and users? What gaps exist, and with what impact?

What is the extent of clarity and certainty in process of need identification (for development outputs)? Can users clearly specify what they need? Do developers know exactly what users mean? Is the developer then able to say with assurance to the user: "This development output is what you asked for"? Is it then obvious to users what to do with the development output?

To what extent (and in what ways) does the developer seek and receive additional information from users during various stages of the development process?

To what extent is it relevant to focus development on technological opportunities (i.e., in the expectation that once developed, the output will be seen by users as "needed")? To what extent do the developers attempt to "forecast" potential user "needs" for development outputs based on technological opportunities? How is such "forecasting" done? By whom (i.e.: by the developers; by use of consultants; by producers; by marketing departments; etc.)?

D. Development State of the Art Linkages

Development generally involves modifying or improving an existing product (process, models, etc.), or turning a well developed concept into a usable product. Thus, development involves using a relatively certain and established knowledge base. Some important issues, then, could be:

What are the linkages that developers have to the development state of the art?

How extensive and established is the development knowledge base with respect to a particular sector, a particular type of development output?

Are developers creating development outputs which are in fact "out-of-date" because the state of the art permits superior outputs to be developed?

E. Linkages to Production

In the generic sense, the end of the development function is the beginning of the production function - - i.e., when a development output is "user-ready", it is ready to be produced. (It must be noted, of course, that a clear cut separation of the development and product functions does not always exist.) However, it cannot be de facto assumed that <u>any</u> "user ready" development output is also "producer-ready" - - i.e., that it is easy to produce. Thus, some important issues could be:

What constraints are there in the production function in relation to development outputs (e.g.: existing manufacturing facilities and technologies cannot produce the development output; cost of modifying or replacing existing equipment)?

Are developers aware of production constraints?

What are the communication linkages between developers and producers?

F. Development Processes

Development may be perceived as a process, involving several steps or stages, though these may differ depending on the nature of the product and on who is the developer. Here, some important issues could be:

What steps are or are not needed? Are any "needed" steps being omitted or done inadequately?

What are the product and process design requirements? Engineering requirements?

What kind of quality control is done?

What are the costs for the development process?

What are realistic time lines for development? What affects the time line (e.g.: nature of the output; availability of personnel, funding, supplies; laws and regulations; etc.)?

Who does/should do evaluation of development proposals, projects, outputs -- i.e., what should be the evaluation role of developers, users, researchers, funding agencies, etc.?

Is testing feasible? What does a test prototype cost? Are required technologies and facilities available? Are the criteria for evaluation simple and clear cut or complex and hard to define?

Can/should the development process be done in clear and separate stages?
What decisions need to be made at the end of each stage?

XIII. PRODUCTION

The production function is a critical linking function within the overall flow of innovation from knowledge production to knowledge utilization. The critical issue is whether or not the production function can handle the results of R&D. Thus, to do research and development without considering whether or how R&D outcomes can/will be "produced" is to risk slowing down the translation of innovation from knowledge production to knowledge utilization - - or even (at worst) to risk making R&D outcomes meaningless in relation to utilization.

In addition to the impact the production function can have on the overall R/D&I process, we may note that the designing of production systems is a process of innovation itself. Further, we also sometimes find the development function occurring within the production function as efforts are made to adjust production to R&D outcomes.

A. Production Processes

We will want to examine various aspects of the production process. Some important issues could be:

How must the product be designed so that it can be produced with existing facilities and equipment? In order to meet specifications? In order to reduce costs? What relative emphasis is to be placed on cost vs. quality in product design?

What are the engineering requirements of production in relation to the nature of the product and the facilities/equipment involved?

What are the requirements for designing the production system (e.g.: building facilities)? How is this designing done? By whom?

What are the requirements for production planning and control (e.g.: how many are to be produced in what order)? How might such requirements constrain the production of new innovations? What methods are used?

What kinds of production operations are called for (e.g.: automation, assembly line, continuous process, intricate/ sophisticated vs. unskilled operations, etc.)? What skills are needed?

How is quality control done? How rigorously?

B. Characteristics of Production Processes

We will also want to examine various characteristics of production processes. Here some important issues could be:

What is the scale and scope of production processes? Are the production processes of sufficient scale or scope to meet the requirements imposed by a specific R&D product or to produce sufficient quantities to meet user needs?

What are the technological characteristics of production techniques and facilities? Is the available technology appropriate and adequate? Is it "in place"? Does the production process require sophisticated technology or relatively simple technology?

What costs are involved? Does production require large or small scale capital, operation and/or maintenance costs?

Is production done in single or multiple unit processes? Are these continuous or separate? To what extent does the work of one production unit affect another?

What skills are required?

Are production techniques and facilities relatively "fixed" - - or are they adaptible and flexible? How is adaptibility/flexibility affected by the nature of the technology; by the scale/scope of production requirements and costs?

What is the rate of change in the development of new production technology?

Is obsolescence a significant problem?

Can parts of the production process be subcontracted? Are they? Which parts?

How do the above considerations vary across institutions within the sector?

How does the nature of the materials involved affect production? Are the materials reactive? Are the materials easy or difficult to work with? Do they have to be transported, stored? Do they have to be transformed?

Are the needed materials available?

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

An R/D&I system comprises all the functions related to knowledge production (KP) and knowledge utilization (KU). For R/D&I to comprise a complete system, there must be a "bridge" over which the work done in knowledge production can be "sent" to users - - or, conversely, over which users may come to "find" results of knowledge production which are useful to them. Such KP-KU linking activities may be (and are) described variously. Although no single descriptive term would likely be adequate to describe all such KP-KU linking activities, the following four terms or categories reasonably well capture the types and broadness of KP-KU linking activities: marketing (which is a producer-oriented description); distribution (which implies the methodology by which and the extent to which KP results are made available to users); dissemination (which has a more general, broad information flow connotation); and diffusion (which implies a less proactive process than the first three terms). We recognize, of course, that these are not completely discrete concepts and that, indeed, they overlap significantly. We also emphasize that these KP-KU linking processes include user-to-user user-to-knowledge producer communications.

A. Organizations

A variety of organizations may be involved in KP-KU linking activities: producers who attempt to market products; users who actively look for products; specialized marketing/distribution/dissemination organizations. Thus some important issues could be:

What types of organizations are involved in marketing/distribution/dissemination/diffusion within the R/D&I system or in relation to a particular KP output or set of KP outputs (e.g.: private/public; profit/not-for-profit; producers/users/intermediaries)? What are their respective roles?

What are the characteristics of these organizations (e.g.: large/small; sector-specific or sector-spanning; level of maturation; stable/unstable; etc.)?

What level of priority and resource commitment do these organizations give to marketing/distribution/dissemination/diffusion?

B. Product Type

The type and nature of the product being marketed/distributed/disseminated/diffused affects the nature of the activities. We here include as "product" any of the range of KP outputs such as methods, processes, approaches, products, etc. - - i.e., any KP "output" that may be used by the user. Some important issues could be:

Are the products simple or complex?

Are there many or few products?

Are the products reactive? (For example, acids react with some containers but not others; educational R&D products may become modified by the way they are used by teachers and students.)

Is there a small or large "mix" of product types?

How do the above considerations affect the requirements for marketing/distribution/dissemination/diffusion mechanisms and systems?

C. User Characteristics

The characteristics of the intended user population will significantly influence the requirements and options available for marketing/distribution/dissemination/diffusion. Here, some important issues could be:

Are there many potential users, or only a few?

Are the potential users relatively homogeneous or heterogeneous in terms of: needs, interests, acquisition/implementation/utilization capabilities, geographic location, type of organization, etc.?

What are the entry points into the user system? Who will make the acquisition decisions? Will these be different in different product types?

What contextual constraints are there in the user system (e.g.: lack of resources to acquire; burdensome funding or bidding requirements; low levels of selection/testing/evaluation or implementation/utilization capabilities)?

What level of awareness do users have about a product; about their need for a product?

Is it relatively easy or difficult to identify which users are the relevant potential target population? To identify/define the needs of various users?

What motivational constraints do the users have in terms of motivation to study, test, evaluate, implement and/or utilize a product (e.g.: time constraints, training requirements, prior bad experiences, etc.)?

What effects do the above considerations have on requirements for marketing/distribution/dissemination/diffusion mechanisms and systems? On policies and strategies?

D. Process Characteristics

The marketing/distribution/dissemination/diffusion function will need to be examined in terms of a variety of process characteristics. For example:

What kind of mechanisms, methods, systems are most appropriate in relation to specific types of products and/or to specific types of users?

What is the level of user trust in relation to the product, the producer, the maketing/distribution/dissemination/diffusion system?

Under what conditions would different methods be considered cost/effective?

What methods and channels are being used? Are not being used? Why not?

Is the marketing/distribution/dissemination/diffusion system user-driven (i.e., essentially controlled by users) or user-oriented (i.e., while user imput is taken into account, their input is not determinative)?

E. System Level Considerations

As we noted earlier, marketing/distribution/dissemination/diffusion is the R/D&I system function which in effect "completes" the R/D&I system by pro-

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viding a "bridge" by which the results of knowledge production functions can be made available to users. Thus consideration needs to be given to "system-level" issues in terms both of the R/D&I system and the marketing/distribution/dissemination/diffusion system. Some important issues could be:

What is the level of R/D&I system maturation? How does this affect the need for/relevance of different marketing/distribution/dissemination/diffusion methods and approaches?

What linkages exist between the marketing/distribution/dissemination/diffusion on the one hand and researchers/developers/producers/users on the other? Are there significant "gaps" in the system?

What mechanisms are used for quality control, storing, retrieval, packaging, and tailoring?

XV. ACQUISITION

The function of acquisition is the beginning of and can critically affect the knowledge utilization part of the innovation process. We will want to understand the acquisition function from several perspectives.

A. Steps in the Acquisition Process

The acquisition process may be seen as having several "steps". However, in practice, these "steps" are not necessarily done in "linear" fashion; some may be given more attention than others; indeed, some may not really be done at all. (And of course, other "steps" could be conceptualized.) These steps include:

1. Awareness

Do users tend to be aware of their need or of innovations first? That is, does awareness of need lead users to search for innovations or does their awareness of innovations create an "awareness" of a need?

In what ways do users become aware either of their needs or of innovations (e.g.: from need surveys; pressure from the environment; critical events; publications; informal communications; meetings; marketing efforts of producers; etc.)

2. Search

What causes users to initiate search for innovations?

How extensive is the search?

Is the search process formalized?

Who does the search?

3. Bidding

Are bids used/required for innovations?

Who determines the "specifications"?

Does the bidding process exclude potential suppliers? How?

4. Testing

Is testing of innovations done before purchase? By whom?

How extensive are the tests?

Do organizational personnel have the capability (training, facilities) for adequate testing?

What are the rating criteria to be used in testing? Who determines them?

Is testing done by the user organization or by some other organization?

5. Evaluation

What criteria are used to evaluate an innovation (e.g.: cost; standards; ease of use; flexibility of use; adaptability to other equipment, products, facilities; etc.)?

Who sets the criteria?

Who makes the evaluation?

6. Purchasing

Who makes the decision to purchase or not, or from which producer to purchase?

On what basis are purchase decisions made?

Is purchasing formalized (purchasing agent or department)?

Are there any kinds of cooperative purchasing/leasing arrangements between institutions, between agencies of a level of government (e.g.: police and fire departments), etc.?

B. Role of Key Personnel in the Acquisition Process

As the above discussion has implied, the acquisition process is significantly affected by which personnel play what roles. Some important issues could be:

What personnel are involved in/have authority over: the setting of criteria for testing, evaluation, purchasing; deciding what is "needed"; making purchase decisions; etc.?

What capabilities and perspectives do these personnel bring to the acquisition process?

What are the roles of: producer personnel; intermediate agency personnel (vendors, professional associations, disseminators, "clearinghouses", etc.); "product champions"; and user personnel (purchasing agents, engineers, higher level decision/policy makers, users of the innovations)?

Are the personnel who make purchasing decisions different from the personnel who will utilize the acquisition? Would the personnel who would utilize the acquisition be capable of making technical evaluations? Do purchasing personnel use different acquisition criteria than do the personnel who would utilize the acquisition? How are such differences resolved? With what effect on acquisition decisions (in terms of the value of the acquisition to the personnel who must use the acquisition)?

C. Acquisition Process Characteristics

Additional issues involving various characteristics of the acquisition process could include:

To what extent is the acquisition process formalized? Which steps?

What laws/regulations or organizational policies/regulations affect the acquisition process?

Is the acquisition process relatively simple or complex?

Are the budgeting and bidding processes flexible or rigid? What time lines are involved in budgeting and bidding processes?

How do these factors affect the potential producers/suppliers?

Is the acquisition process centralized or diffuse?

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Are there any inter-organizational purchasing arrangements?

What capabilities do organizations need and have to identify, select, test, evaluate innovations?

What are the intraorganizational linkages (e.g.: between user personnel, engineers, purchasing agents)? What are the interorganizational linkages (e.g.: between producers and user organizations)?

XVI. IMPLEMENTATION/UTILIZATION

Implementation and utilization begin after a user has actually acquired an innovation. It is important to realize that there are some significant differences between implementation and utilization. Essentially, implementation refers to the installation and initial use of an innovation. Utilization refers to the continued, sustained use of an innovation. While there is little merit in trying to delineate precisely where implementation ends and utilization begins, there are some significantly different dynamics between the two. For example, during implementation, the user is dealing with a relatively new phenonemon; during utilization, the innovation becomes "familiar". Indeed, failure during implementation may prevent (or at least set a negative "tone" for) sustained, continuing utilization of an innovation.

At the same time, however, many of the relevant issues are very similar, and it is for this reason that implementation/utilization is considered here as a single function. With an awareness of both the differences and similarities between implementation and utilization, the researcher or policy/decision maker can determine (in a specific instance) the extent to which implementation and utilization may be considered simultaneously or need to be considered separately.

The items below illustrate the kinds of issues relevant to implementation/ utilization.

A. Implementation Processes

Important implementation process issues could include:

Activities of producers/users/intermediaries to prepare for implementation -- What training of user personnel is provided? What preparation must be made for support services such as accounting, computer programming? What supplies must be ordered? Are organization development activities needed to prepare for implementation?

Installation -- What personnel skills, facilities, technologies, etc. are required?

Testing/debugging -- Does testing "destroy" or "use up" the innovation? What are the costs of testing (to do the testing; of the innovation if it cannot be reused after testing)? Can testing be done through simulation, mathematical models?

Trial run -- Are trial runs needed? Feasible? Who does it (producer, vendor, user, etc.)? What are the objectives of trial runs? What time and cost are involved? What effect do the trial runs have on user receptivity to the innovation?

Monitor/evaluate/modify/feedback -- Are these feasible? How are they done? By whom? What is the quality of the data received?

The main issues for implementation, then, concern: what is needed and/or available; who is/should be involved; how implementation is done; and what the effects of implementation will be.

B. Utilization Processes

Important utilization process issues could include:

Expansion/replacement -- In what ways does the innovation require or allow expansion of the organization's capabilities, facilities, support services, etc.? What does the innovation replace in terms of previous technology, equipment, personnel, etc.?

Routinization/standardization -- How is usage of the innovation routinized and standardized?

Monitoring/evaluation/modification -- What are the processes for monitoring, evaluation, modification?

Acceptance/institutionalization -- Has the innovation been accepted within the organization on a continuing, sustained basis? Has it been "institutionalized" (i.e., has it become basic/essential to the organization, or has it remained peripheral)?

Maintenance -- What costs are involved in maintenance? What support services, personnel, training of personnel must be provided for maintenance?

Extension/improvement -- In what ways can/will the innovation and its usage be extended or improved over time? What will be required? Will the innovation be utilized in stages?

Diffusion -- Is this innovation diffused throughout the organization, or is it utilized in only a segment of the organization? If the latter, why?

C. Implementation/Utilization Process Characteristics

Important implementation/utilization process characteristic issues could include:

Scope -- What is the scope of activities and system adaptation required? What resources are needed? Who is/must be involved?

Level of technology -- What level of technological sophistication is required? For what technologies? Is training required?

Constraints -- What constraints exist? Can these be removed or reduced? How? At what costs?

Acceptance/rejection -- What actual or potential conditions will tend to affect the acceptance or rejection of the innovation?

Adjustments -- In what ways must the innovation be adjusted in order to adapt it for usage in a specific setting? What adjustments will be called for within the organization?

Impact -- Who/what organizational activities will be affected? In what ways? What organizational changes will be needed?

D. User Characteristics Influencing Implementation/Utilization

Important user characteristic issues influencing implementation/utilization could include:

Incentives/barriers -- What are the incentives and/or barriers for users in the process of innovation? What are the "entry points" for innovation? What is the history of innovation in the user system? How do these differ between organizations and within specific organizations?

Capabilities -- What capabilities do users need for implementation/utilization? Do they have or lack such capabilities? Which user organizations and/or personnel? With respect to which aspect of implementation/utilization processes?

Key user personnel -- Who are the key user personnel? With respect to what aspects of implementation/utilization? Who are the user change agents and opinion leaders?

Status relationships of innovation -- Does the innovation provide status for the organization or organizational departments or personnel? Is there professional status associated with the innovation?

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Organizational characteristics -- How do organizational structures, processes and climate impact upon implementation/utilization?

E. Producer Characteristics Influencing Implementation/Utilization

Depending upon the nature of the innovation and the needs of the user organization, the producer may be a significant influence on implementation/utilization. Important issues could include:

What need does the user have for producer help in implementation/utilization?

What is the capability of the producer to provide such help (e.g.: the producer's ability to train user personnel; the producer's technical capabilities)?

What is the willingness of the producer to provide such help? What incentives does the producer have? Does the producer provide such service as a standard procedure? Is the particular situation of special importance to the producer?

F. Producer/User Relationships Influencing Implementation/Utilization Processes

Producer/user relationships may also affect the implementation/utilization process. Some important issues could be:

What are the user's relationships with the producer? Is the user dependent on the producer? In what ways? Are alternative sources (producers) available to the user? Is the user aware of these alternative sources? If not, why not? Does the user "favor" one source over another? If so, why and with what effects?

Do organizations other than the producer help the user implement and/or service the innovation? What organization? What is the user's relationship with these organizations?

XVII. SUPPORT SERVICES

Although it might be theoretically possible to conceptualize an R/D&I system which would be completely self-contained, in reality an R/D&I system and its constituent institutions do require support services from other systems, organizations and/or sectors. The need for support services will be relevant (though different in specifics) for all of the R/D&I functions.

A. Support Service Requirements

We would want to know the nature and extent of the R/D&I system's requirements/needs for support services. Thus, some important issues could be:

What are the R/D&I system's requirements/needs for support services (e.g.: protection of proprietary rights; testing and analysis; equipment; supplies; transportation; computer services; maintenance services; etc.)?

How do these requirements/needs differ according to level of system maturity, R/D&I function, R/D&I institutions, type of innovation involved, etc.?

What level of sophistication and/or specialization is required in the support services?

What services are the R/D&I system or institutions unable to provide for themselves? What services _should_ they not provide for itself? Why not?

How dependent are the R/D&I system or institutions upon the support services? What are the effects of such dependence?

What combination of rent/buy strategies (for obtaining support services) are most appropriate at a particular time, under existing condidions, for a particular type of support service, etc.?

B. Linkages to Support Services

It would be important to know how the R/D&I system and its institutions are (or could be) linked to support services. Some important issues could be:

What linkages exist between the R/D&I system/institutions and the required/needed support services?

What gaps are there? What is the impact of these gaps?

What barriers/constraints to linkage exist (e.g.: legal contraints; slow payment by public agencies for services received; support service system not being interested in the particular R/D&I system or sector)?

C. Support Service Characteristics

We would want to know something about the nature and characteristics of support services. For example:

To what extent are the required/needed support services available or not? Are there significant delays in obtaining support services?

What is the level of technical capability of the support service systems?

What is the quality of support services available?

What are the costs involved?

What are the sources of support services? Are there alternative sources from which to choose? If so, what are the significant differences between them?

XVIII. EVALUATION RESEARCH

The evaluation research function is often simply called "evaluation". We have deliberately chosen to use the term "evaluation research" to indicate that while evaluation is done in relation to knowledge utilization, there is a research/knowledge production component to evaluation. Thus, while evaluation research is done to inform funders, policy makers, decision makers and managers, it does create knowledge which (in turn) expands the knowledge base for R/D&I.

A. Two Kinds of Evaluation Research

Evaluation research may be either of two basic kinds. On the one hand, it may be done for the purpose of providing policy/decision makers with data on which they may base decisions to continue, discontinue or modify a program, project, etc. -- or simply to "evaluate" the effects of a program/project. In either case, the focus is on "end results", and the evaluation research would usually be done only after a significant period of time had elapsed since the beginning of a program, project, etc. -- e.g.: upon the completion of a program, project, etc., or at some regularly scheduled, but fairly long, intervals (e.g.: annually). This kind of evaluation research is often called "summative".

On the other hand, evaluation research may be done on an ongoing basis during the life of a program, project, etc. Here the purpose is to provide managers with data upon which "mid-course", operational changes can be made as needed. This kind of evaluation research is often called "formative".

There are potential conflicts between the two types of evaluation research. In summative evaluation research, premium would usually be placed on avoiding input which could alter the program, project, etc. -- in order to avoid "contaminating" the research process. In formative evaluation research, however, premium is given precisely to inputs which would allow such alterations. Similarly, the research designs tend to be different for these two types of evaluation research.

Some important issues could be:

Which kind of evaluation research is being done?

What are the objectives of proposed evaluation research? Which kind of evaluation research is needed to accomplish these objectives?

If both kinds of evaluation research are done, can they be done within the same research design, or must the research designs be different? Would the research evaluators who do the formative evaluation research be able to be objective about the summative evaluation research?

What are the similarities, differences and/or conflicts between methodologies for formative and summative evaluation research?

At what points in the evaluation research process should formative evaluation be undertaken? By whom?

What are the implications for evaluation research if the focus of evaluation is short-term as compared to long term? If the focus is on consequences related to the immediate user as compared to consequences related to society?

B. Significant Participants

Evaluation research involves a number of different participants, each of whom may have somewhat different (and potentially conflicting) objectives, needs, interests, etc. Thus, some important questions could be:

Who are the significant participants (e.g.: the evaluation researchers; funders; policy makers; decision makers; managers; staff; external political or pressure groups)?

At what levels or in what parts of the system are the participants located (e.g.: local, state, federal levels of government; top level managers; functional managers)?

What are the information needs, perspectives, "vested interests", objectives, roles of the participants? To what extent and in what ways are these perspectives, etc. different or in conflict?

What is the nature and history of the relationship between the participants (e.g.: collaborative, conflictual, none, etc.)?

Who controls the problem definition (i.e.: decides what is to be researched and evaluated)?

Who determines what criteria and methodologies are to be used?

Who determines whose information needs will/will not be met?

Who has access to the evaluation research results? Who determines access?

Who determines how the evaluation results will be used?

What is the role of the evaluation researcher in determining problem definition, criteria, and access to results?

What skills do evaluation researchers need to have? Do these skill requirements differ for the design, data gathering, data analysis and data reanalysis stages? In terms of types of innovations? Do the skill requirements differ between formative and summative evaluation researchers?

What is the training and background of the evaluation researchers?

C. Type of Program or Project

Evaluation research is done in relation to some specific program or project (or service, etc.). The nature of the program or project may affect the type of evaluation research that is relevant, the extent to which it is feasible, the reliability and validity of results, etc. Thus, some important issues could be:

What is the nature of the program or project (e.g.: large or small scale number and type of people involved in or affected by; level within system; social service or physical science based; length of time before "results" can reasonably be expected; etc.)?

Are the goals/objectives of the program or project clear?

In what ways and to what extent does the nature of the program constrain the feasibility, reliability or validity of evaluation research?

Can direct "measurements" of outcomes be obtained (or can they be obtained only after long periods of time)? Are "secondary" or "predictor" indicators available? With what degree of reliability and validity?

D. Design Methodology and Process

On the one hand, evaluation research utilizes the methodologies of many research disciplines. On the other hand, evaluation research is seen by many as a distinct discipline itself. In any event, the nature of the evaluation research design affects the results obtained. We may further note that because of the variety of participants and the potential for conflict among them, the design process takes on special significance for evaluation research. Thus, some important issues could be

What methodologies are used for evaluation research?

To what extent are the methodologies validated, replicable? In what fields, disciplines, sectors? To what extent does the nature of the program or project (or the situational context) constrain validation and/or replication?

What are the criteria upon which evaluation will be made?

How are the evaluation criteria developed? By whom?

Have potential conflicts in data interpretations, usage of results and access to results been identified prior to designing the evaluation research process? If so, how will these considerations be built into the design process; and/or what steps will be taken to deal with the potential conflicts?

XIX. RESEARCH ON R/D&I

It is important to know what research has been done (and what data has thereby been obtained) about R/D&I. This would include policy research/policy analysis done for an R/D&I system institution, research on any of the R/D&I features, research on R/D&I systems in general, contextual analyses relevant to particular R/D&I systems, and research on research (R^2).

Some important issues could be:

Control -- Who determines what research on R/D&I will be done, how it will be done, who has access to data findings, how findings will be used?

Focus -- On what aspects of R/D&I does the research focus?

Methodology -- What methodologies are used? What are the strengths and weaknesses of the methodologies?

Scope -- Is the research narrowly or broadly focused?

Generalizability -- To what extent are the implications of the findings generalizable?

Institutionalization -- Are there research organizations or departments which focus on research on R/D&I? Or is the research on R/D&I being done by individual researchers or small research teams apart from any institutionalized base? Is research on R/D&I done on a continuing or on an occasional basis?

Developmental state -- For what aspects of R/D&I is research at a high or low level of development?

Literature base -- How adequate is the literature in regard to the empirical and theoretical bases for research on R/D&I? What information do we have about R/D&I? How valid and reliable is the information? What "gaps" exist?

Utilization -- How have research findings been used (or not used)? Why or why not? By whom?

Impact -- How have the research findings affected R/D&I systems? What are the implications of the research findings for R/D&I? For which R/D&I systems? For functions or aspects of R/D&I systems?

Control -- Who determines what research on R/D&I will be done, how it will be done, who will do it, who will have access to findings, how findings will be used?

R^2 -- What research is being done (and by whom) about the nature and process of research on R/D&I?

The Research on R/D&I Community -- What is the need for encouraging the development of the communities of researchers on R/D&I? How might this best be done in order to balance both short term and long term impact?

SECTION TWO

ILLUSTRATIVE CONTEXTUAL ANALYSES OF SELECTED R/D&I SECTORS

CHAPTER THREE

THE R/D&I CONTEXT IN THE EDUCATION SECTOR

THE R/D&I CONTEXT IN THE EDUCATION SECTOR

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IV. GOALS, POLICIES, STRATEGIES
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CHAPTER THREE

THE R/D&I CONTEXT IN THE EDUCATION SECTOR

A volume-length analysis of the educational R/D&I context is in preparation and will be on file at the National Institute of Education (NIE). In the chapter presented here, we summarize key points made in the lengthier analysis. Specifically, each of the 19 contextual features will be reviewed below to describe the context for analysis of the educational R/D&I system.

It should be noted that much of this analysis is based on impressionistic sources -- impressions derived from immersion in the literature [illegible] to analysis of key features of the educational R/D&I system and impressions derived from the analysts' personal experiences and familiarity with the educational R/D&I and operating systems. The lengthier analysis provides extensive citations and other documentation, as well as some discussion of key points in need of empirical verification.

I. ENVIRONMENTS OF THE R/D&I SYSTEM

1. Vulnerability

A. A Public Base

Of all the sectors we have considered in our comparative analysis, education is clearly the most vulnerable -- the most open to (and subject to) social and political influence.[125] As public service institutions supported by public funds and administered and regulated by public agencies, schools affect all subgroups of the population (as citizens and taxpayers). Since the proportion of local funds spent on public education tends to be quite high, schools tend to be particularly salient to taxpayers. For those taxpayers who are also parents of school-age children, the level of concern about school functioning tends to be even higher -- American society has been characterized by tremendously high expectations for schooling. The business community, too, has been expressing great concern about school functioning, bemoaning the poor quality of work force preparation for the world of work.(24)

B. Goals

Education, by its nature, also has more diffuse goals than other sectors -- goals that are more subject to value-laden judgments, misinterpretations, and controversy; goals that are harder to specify, less measurable, and harder to use as performance standards against which to judge system performance.(125) In comparison to other sectors, then, the functioning and effectiveness of educators, educational R/D&I personnel and the educational system as a whole are more likely to be subject to scrutiny and debate.

C. Legitimacy Problems

Contributing to the vulnerability of the education sector is the educator's legitimacy problems in claiming specialized expertise and professional status. Compared to scientists, engineers, doctors, or lawyers, the specialized training needed to function as a teacher or principal does not seem particularly awesome. From their own personal experience (as well as close observation of the experience of others), the public has more familiarity with what the educator does (as compared to knowing what an engineer or a lawyer does). Therefore, particularly for the better educated parent, there is far less of a gap in expertise between the general public and educators than between the public and professionals in fields with strong knowledge or technology bases. Similarly, compared to fields with well developed knowledge and technology bases and highly specialized development activities (e.g.: engineering), there does not appear to be much of a gap in expertise between the R&D personnel who develop many of the learning materials on the market and the teachers who develop their own materials, or even parents who peruse the materials used by their children.

D. The Nature of Educational Innovations

Adding to the vulnerability of educational R/D&I is the nature of educational innovations, as compared to the more technologial outputs of R/D&I systems in other sectors, where R&D products are easily packaged and installed; where use rarely conflicts with the values, attitudes, and sensitivities of operating system personnel; and where products can be expected to behave reliably in accordance with their performance specifications (as long as they are used properly). Educational innovations, in contrast, tend to involve "people change" -- e.g.: creation of new capabilities or organizational strategies or instructional approaches. They are therefore more likely to be resisted -- by the people who make adoption decisions and by those who must implement them. As "people change" products, there is far greater reactiveness between product and users (both school personnel as intermediate users and students as end users). Therefore, implementation is more difficult, and effects are far less predictable. Even when effective, educational innovations are harder to prove effective -- their effects are harder to demonstrate objectively and are therefore more subject to dispute. Further, there may be controversy over the desirability of intended effects. (48, 59, 61, 74)

E. Weakness of the Scientific and Technological Base

The weakness of the scientific and technological base of education and educational R/D&I is at the crux of much of the environmental vulnerability of this sector. Though it shares much common ground with the social sciences and other applied social science fields as well, education is particularly vulnerable here. For example, we may note the following:

1. The development of a knowledge base in the social sciences and applied fields like education involves research on humans rather than non-humans, and this raises numerous value questions about what should be studied and how; (48, 50) the ethics of research; safeguarding the rights of those studied; etc.

2. It also entails greater uncertainties in the research situation since the humans studied (unlike rocks or molecules) have and exercise free will and are thus "reactive" to innovations.[48, 50] Therefore, reliability issues become particularly troublesome.

3. There is also a greater likelihood of bias creeping in through the researcher's own biases or the quality of the interaction between researcher and subject.

4. Experimental designs calling for randomization or various kinds of controls are also less feasible with humans, especially in field settings as opposed to laboratory research.[53]

2. Governance Structures

A. The Value Problem

The value-laden nature of education and educational R/D&I is particularly problematic, given the governance structure of education and educational R/D&I. School systems are legally controlled by agencies in their environment. Both school systems and educational R/D&I institutions are largely dependent on these agencies for their funding. Legal control over the operating system is vested in lay boards of education, elected (or appointed by elected officials) in each of the approximately 17,000 school districts across the country. This lay control, its relationship to political processes, and its extreme decentralization are factors of some consequence. Although professional (i.e.: the Superintendent) dominance of lay boards is the rule, there are frequent exceptions. Especially in controversial areas (e.g.: busing, sex education), unless the Superintendent is a person with strong leadership abilities and a clear vision of what he or she wants, community pressures can have a major impact on school functioning.

B. Formal Governance Structures

In terms of formal governance structures, the educational system in the U.S. is characterized by extreme decentralization. In contrast to centralized systems (as in France, for example) which have centrally prescribed courses, textbooks and learning materials, centrally developed examination systems, and extensive monitoring of school operations by school inspectors, each of the thousands of local school districts in this country is largely autonomous. Though legal authority to regulate schooling is vested in the governments of the states, few if any states actively monitor school functioning, and on the whole, local districts are highly autonomous from state and federal authorities. In operational terms, decentralization tends to go considerably beyond the decision making autonomy of the districts. Within each district there is considerably autonomy at the the local school level, with the principals (and also teachers) having a great deal of leeway in determining what happens in their classrooms. This degree of autonomy down to the school and classroom level is a factor of considerable importance in explaining why innovations that are formally adopted by a school district are so often not implemented in practice, or are so transformed during implementation that they amount to little more than "the same old thing".(51, 119)

C. Funding Control

In the case of the educational R/D&I system, the ultimate control over decisions affecting funding -- and ~~therefore R/D&I~~ functioning -- is the Congress. Given the history of Congress's lack of confidence in the ability of educational R/D&I to provide a reasonable return on the taxpayer's investment, this has meant almost constant troubles for the R/D&I system.

3. Economic Forces

Economic forces in the environment of the educational operating and R/D&I systems have been felt particularly severely in recent years. On the state and local level, school financing has become one of the paramount issues of the day. We find increasing numbers of cases of states and local communities struggling over equitable financing formulas; states cutting assistance to local districts as they struggle with their own financial difficulties; and voters in local districts defeating school budgets and bond issues in an effort to stave off further increases in local taxes. Economic recession has also meant a shortage of slack resources in the private sector to invest in high risk/low return R/D&I activities.

4. Summary: Weak Supports and Assertive Demands

In all, we can characterize the environment of the education sector as one that tends to be weak in supports for the system and assertive in demands about what can or cannot be done, should or should not be done. R&D in education tends to lack prestige or legitimacy -- or even a strong demand for its products or its very existence. This seems apparent whether we focus on the attitudes of researchers and scholars in the disciplines, educational practitioners, laymen, Congressmen, or even the education research and R&D communities.. The system appears to have developed no strong constituency of its own and is buffeted by the initiatives of various other constituencies able to articulate demands reflecting broad social, cultural, and political movements in the society as a whole (e.g.: integration, ethnic consciousness, feminism).

The environment of the education sector affects virtually every feature of the R/D&I system -- the definition of goals, needs, and strategies; the level and quality of personnel, funding, and other resources that flow into the system; and the functioning of the system itself (what research problems or R&D topics are attended to; the manner in which problems are defined; the amount that must be invested in early phases of R&D activity because of the weakness of the knowledge base and the transforms between stages; the controls that are exercised over research to protect human subjects; the credibility of the research and R&D effort with different constituencies (as evidenced for instance in the numerous examples of the black community's unwillingness to participate in survey research in the late '60s). No other sector we have considered in our comparative analysis is confronted with such serious environmental pressures. None is as dependent on environmental institutions for its support. And none is dependent on an environment so inimical to its chances for development and maturation.

II. HISTORICAL DEVELOPMENT

1. A Newly Institutionalized System

The development of instructional strategies and learning materials has been going on as long as there have been teachers and students, and we can find examples of institutionalized educational research in this country over a relatively long historical period. Nonetheless, we must note that institutionalized R/D&I in education is only a little more than a decade old. That is to say, new to the field of education is institutionalized, linked R/D&I as an interrelated set of processes revolving around the development function and carried out by specialized personnel under specially designed organizational arrangements. While the newness of a system may not be significant in itself (few institutionalized R/D&I systems in any sectors are more than a few decades old), it is a factor of some consequence when compared to the centuries of history and tradition that characterize the operating system of educational institutions. The operating system served by educational R&D is old in history and heavily laden with traditions, norms, and values that run counter to the acceptance of outputs of external R&D.

Thus, the educational R/D&I system has not yet established its legitimacy. It competes against traditional approaches to producing knowledge, programs, and products for educational institutions -- and it uses scarce resources. Its methods and outputs have not yet proven their superiority to traditional methods and outputs. In many cases, the products of educational R/D&I appear to be clearly inferior to conventionally developed products.

There would seem to be abundant evidence that the system's present state of maturation places it within the boundaries of the introductory stage of historical development. It is a relatively young system. As we will discuss later in this analysis, many functional specialties of mature R/D&I systems are almost totally absent in education. Those that do exist either emerged as areas of specialization after the R/D&I system was institutionalized in the mid-'60s, or were wholly transformed by the demands of that system. The functional specialties provided in the specialized R/D&I institutions exist alongside of -- and compete with -- similar activities carried out in the other, older parts of the education sector. The system has been characterized by a high level of instability in both macro and micro level structures. Neither its funding nor its personnel bases have been adequate to the demands of system functioning or appropriate to the quantity and quality of outputs expected by the system's sponsors. The field's knowledge and technology base is inadequately developed. R/D&I functioning in education has been hampered by amorphousness of standards; ambiguities in defining work roles and requisite skills and compentencies; and inadequacies in information flow. The knowledge producing and knowledge utilizing components of the system are poorly integrated. System outputs have been generally low in quality.

2. Critical Events

A. 1954-1972

A number of critical events have shaped the system, brought it to its current point of development, and continue to be felt as constraints on system functioning. The most significant events in the birth of institutionalized R/D&I in education are: (1) the emergence of the federal government as the primary sponsor of educational R/D&I in the mid-'50s; and (2) the enormous expansion of federal funding programs in the '60s. The most important legislation has been: (1) the Cooperative Research Act (1954 and subsequent amendments); (2) the National Defense Education Act (1958); and (3) the Elementary and Secondary Education Act (1964).[39, 93] Through these pieces of legislation, the federal government created major new funding programs and also created a network of new Office of Education (OE) funded institutions which were separate from the existing bases of R/D&I activity and external to the operating system.

The new network of R/D&I institutions external to the operating system included: university-based R&D centers, regional laboratories established in the form of quasi-public corporations located in non-university settings; ERIC clearinghouses; ESEA Title III demonstration centers; and various kinds of materials centers. Although both the laboratories and centers were expected to carry out activities covering the full range of R/D&I activities, the academic locations of the centers suggested that they would be particularly well suited to conduct research and prototype development; the laboratories, as institutions apart from the research subculture of the universities, were expected to be in a better position to attract full-time development-oriented personnel, and were therefore expected by many to carry out much of the system's R/D&I activity oriented toward full development, testing, and packaging of prototypes into usable products and program packages. As it turned out, especially in the initial years of functioning of the new network of institutions, there was only a limited amount of this functional specialization, and (with some exceptions) the laboratories and centers operated independent of one another's work, each attempting to carry out the full range of research, development, and dissemination work connected with its products. Adding to this picture of minimal integration among system institutions, the dissemination-oriented institutions in the system (e.g., the ERIC clearinghouses, ESEA Title III centers, materials centers, etc.) tended to define their agendas and carry out their activities in ways that were for the most part unrelated to the work of the laboratories and centers. High quality outputs were expected to materialize quickly from this new network of institutions and to have immediate and widespread impact on school system programs and practices. When this goal was not achieved within only a few years, Congressional disillusionment set in; large numbers of laboratories and centers lost their funding and went out of existence; and educational R/D&I appeared to be in deep trouble. (There were 13 R&D centers and 20 laboratories by 1967; by 1972, only 23 of these 33 remained; by 1975, only 17 of the 33.)[93]

The educational R/D&I system, as that system is generally conceived today, encompasses an institutional base considerably broader than the labs and centers and other specialized R/D&I institutions newly created by the Office of Education in the '60s. It includes work carried out in academic institutions, in the private sector, in federal, state, and local agencies, etc.[88] And recent analyses of the federal government's sponsorship of educational R/D&I activities underscore how many different federal agencies and programs fund educational R/D&I efforts.[76, 77, 78, 102] Future histories of educational R/D&I, and especially federal sponsorship of educational R/D&I activity, are likely to meet the as yet unmet need for analysis of significant patterns in R/D&I functioning in this broader set of R/D&I performers and sponsors. At present, however, based on available published sources, there is relatively little that we can say about how this broader system fared in the '60s, and early '70s. Still, whatever picture of educational R/D&I in these other settings may appear in some future histories, the visibility of OE funding for educational R/D&I in these years (in contrast to funding for such work from other agencies), and the close association in the minds of many (e.g.; Congressional critics, practitioner critics, etc.) between the labs and centers on the one hand and the sum total of educational R&D on the other suggest that the successes, failures, and fate of the labs and centers in these early years might affect the broader educational R/D&I system and its sponsorship for some time to come regardless of whatever may be learned subsequently about the broader system, its functioning, and its outputs.

The ups and downs in Administration and Congressional support for educational R/D&I have had a critical impact on the system since there are so few other bases of R/D&I funding. The R/D&I funding that comes from private foundations is small in comparison to the sums invested by federal agencies. (In FY 1968, private foundations provided approximately $7 million of a $192 million documented minimum base of financial support for educational R&D.[103] For FY 1975, private foundations were estimated to provide $57 million to $65 million of a total of $605 to $673 million of educational R/D&I funding in this country.[102]) Furthermore, potential bases of funding -- the education industries, entrepreneurial firms, state and local educational agencies -- have until recently failed to allocate substantial resources to R/D&I activities, and even now the amounts that come from these other potential bases of funding are relatively small (somewhere between $35 and $85 million annually).[93]

B. 1972 - NIE

The educational R/D&I system was given a brief reprieve from what appeared to be an inevitable premature death. In 1972, the National Institute of Education was created, and control over many of the OE-sponsored R&D programs were transferred to this agency (especially those programs like the labs and centers program which had come under Congressional attack). NIE was given a legislative mandate "to build an effective R&D system." Implicitly, it appeared that NIE was to become the lead agency for the federal government sponsorship of R/D&I in education and that its fate would become synonymous with educational R/D&I -- as had the OE-sponsored labs and centers program in the '60s.

Unfortunately, the Institute itself encountered almost immediate problems of its own, the most serious of which were its appropriations struggles with the Congress. In 1974, federal funding for NIE (obligations) was cut, from $106.8 million in FY 1973 to $75.7 million in FY 1974, a figure lower than equivalent OE educational R/D&I program allocations had been since 1965. The zero funding recommended by the Senate threatened the very existence of NIE and implicitly educational R/D&I in general. Since 1974, NIE's funding status appears to have stabilized (albeit at the rather modest $70+ million level). Still, the key barometer of this relationship for the near-term and long-term future is likely to be the extent to which the Agency succeeds (if indeed it does at all) in substantially increasing its appropriation.

NIE has been in existence for only a few years, and efforts to contrast NIE policies and orientations with previous federal educational R/D&I policies are hazardous -- given how little evidence is available about federal sponsorship of educational R/D&I activity outside of OE and federal funding targetted at institutions other than the OE-created labs and centers. Still, our observations and impressions of federally-sponsored educational R/D&I functioning in the pre-NIE decade and subsequent period suggest the following strong points in NIE's favor that seem to warrant mention.

In contrast to OE policies in the '60s that focused so much attention on the labs and centers, NIE policies and programs appear to have restored greater balance to overall system development. By supporting both the traditional bases of R/D&I activity (academic institutions, private sector organizations and the operating system) as well as the new institutions that emerged in the '60s, NIE has been supporting sources of educational innovation that are both internal and external to the user system. NIE program funding emphasizes not only research and development activity (as did OE in its funding of the labs and centers), but also dissemination, delivery, and building internal user system capabilities for need identification, development, implementation, and utilization. State education agencies have been taking increasingly active leadership roles in dissemination and in providing technical assistance to school systems. NIE has also been emphasizing the role of the state education agencies as key sources of leadership in these areas.

But NIE has not as yet developed a strong constituency within the research and R&D communities and among the powerful education interests and lobbies. Consequently, educational R/D&I continues to be buffeted by environmental forces, with little prestige or clout of its own to buttress it against environmental pressures that impair system functioning. Educational R/D&I has been likened to a tree that is planted and then torn out by the roots every couple of years to see how it is growing. To understand why this has been so, we must examine the environment of educational R/D&I.

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

Analysis of the structure of the educational R/D&I system suggests the existence of several parallel subsystems characterized by minimal specialization, considerable redundancy, looped as well as adjacent clusterings of functions, major gaps between functions, and inadequate linkages among subsystems as well as functions. The overall structure is diffuse, much of it lacks formalization, and whatever centralization or coordination might seem to be inherent in the dominant role of the federal government in R/D&I sponsorship is more potential than operational at this time.

The focus of our attention here is on the network of institutions that carry out R/D&I activities per se rather than either the superordinate system that provides resources and contraints and accepts system outputs (i.e.: the federal and to a lesser extent state agencies and private foundations) or the subordinate system of mostly sector-spanning organizations that provide support services (e.g.: data processing service bureaus, equipment suppliers, maintenance firms, etc.).

ERIC

1. Parallel Subsystems Within the R/D&I System

The structure of the educational R/D&I system is, in reality, a set of three parallel subsystems.

A. Colleges and Universities

One subsystem is made up of various organizational settings located within the colleges and universities -- schools, colleges, and departments of education; educational research bureaus; various academic departments in the social sciences and occasionally other disciplines as well; and university based interdisciplinary research centers and institutes.

B. Quasi-Public and Private Sector Institutions

A second subsystem parallel to the first is made up of the large and proliferating number of quasi-public and private sector institutions currently engaged in educational R/D&I -- the federally funded regional laboratories, R&D centers, ERIC clearinghouses, materials centers, etc.; non-profit and for-profit research corporations geared to the federal grants and contracts economy; organizations from private industry that have been making tentative forays into educational R/D&I; and others such as publishers and audiovisual firms that have strong, established footholds in the education sector.

C. SEAs, ISAs, and LEAs

The operating system of State Education Agencies (SEAs), Intermediate Service Agencies (ISAs), and Local Education Agencies (LEAs) are so weakly linked to these other two subsystems, and often so redundant with them in the conduct of R/D&I activities, that we have identified the operating system as a third, parallel stream rather than as the KU target of KP activities in these other two streams.

ERIC

D. Linkages Within Each Subsystem

Within each of these subsystems there is some interaction of a more or less informal nature -- but far less than one would imagine given the physical proximity of organizational units within the academic setting; or given the operating system's formal governance structure that would lead one to expect to find extensive interaction and monitoring between SEA and LEA personnel; or considering the commonality of interests that would lead one to expect extensive communication among schools or between LEAs and SEAs.

ISAs represent a new development aimed at increasing linkages among school districts, and between school districts and their SEAs. Aside from this one exception (and even here, only some states have created ISAs -- and these tend to be quite new), linkages within each of the three subsystems are incidental and informal rather than institutionalized, permanent, and strong. Consequently, communication and information flow are weak, and knowledge production and utilization are inefficient and far less effective than they might otherwise be. Developments in social science departments tend to have relatively little impact on developments in schools of education. R&D activities in one research corporation have little impact on R&D activities in others. As yet, local innovations in one school district seem to have little impact on practices in other districts.

E. Linkages Between Subsystems

Equally (and perhaps even more) serious are weaknesses in the linkages among these parallel subsystems. The academic community tends to function in relative isolation from both the operating system and the research corporations that dominate R&D activity. Consequently, the research findings produced by the universities have relatively limited impact outside that subsystem. The operating system is linked to publishers and equipment suppliers in the private sector but otherwise generally develops its own programs and materials and tends more often than not to operate as though there were no educational research community, no relevant research findings, and no [illegible]ally developed R&D products and programs. (9, 51, 54, 57, 139) The general pattern in the regional laboratories and the research corporations is to develop products and programs in relative isolation from either the academic community and its accumulated knowledge base or the user system and its perceived needs and constraints. There are notable exceptions, of course, and some strong collaborative arrangements have been forged in a number of instances (e.g.: Northwest Regional Laboratory in relation to school districts in its region). But on the whole, individual R/D&I institutions and organizational units tend to function in isolation, linked weakly if at all to other institutions or units or their immediate subsystem or other subsystems in the macrostructure.

2. A Linear Model in Theory but not in Practice

A. A Low Degree of Functional Specialization

The linear model that is now in general disrepute but seems to have been a significant influence on much of the early R/D&I thinking in the '60s assumed that a "natural" specialization of functions and a pass-it-on flow of R/D&I activity would emerge in the relationship among these subsystems. The university subsystem seemed inherently suited to research; the non-university corporations seemed designed to meet the needs of programmatic development work; and the operating system was viewed narrowly as the target to receive the outputs researched in the universities and developed in the corporations. Functional specialization was assumed, as were the linkages, two-way interactions, and knowledge feedback flows required for an integrated system. To whatever extent the linear model may be accepted as a reasonable description of R/D&I configurations in any other sector, empirical reality in the education sector reveals a somewhat different picture.

The relatively limited degree of specialization and extensive amount of redundancy that characterize the educational R/D&I system can be seen in the location and clustering of R/D&I functions in the various institutions that make up the system. The greatest amount of specialization occurs at the basic research end of the educational KPU spectrum, with most basic research concentrated in the universities and especially in the academic departments. Some basic research is done in some of the larger, wealthier, and more prestigious corporations (e.g.: Educational Testing Service). But for the most part, basic research is the private preserve of the universities.

Applied research, however, is carried out in one form or another in research institutions or units scattered throughout all the various types of organizational settings in the system -- the universities; the R&D centers and regional laboratories; the research corporations; and even some of the strong SEAs and big-city LEAs that have the resources to carry out policy research as part of their long-range planning and monitoring efforts.

The bulk of federally funded development work is carried out in the regional laboratories and the large research corporations. However, development work in one form or another takes place in virtually all types of organizational settings in all three subsystems. Similarly, dissemination and evaluation contracts are being awarded increasingly to institutions located in only certain segments of the overall structure (dissemination contracts increasingly to SEAs and organizations working with them; evaluation contracts increasingly to the research corporations). Nonetheless, dissemination and evaluation activities, too, are carried out in one form or another throughout the structure, even in organizational units within the superordinate structure of federal and state agencies.

If we consider the implementation and utilization support functions, what little linkage specialization exists to provide user system personnel with technical assistance in building internal capabilities or implementing externally developed R&D products, tends to be located either in new linkage and technical assistance organizations (generally small non-profit corporations) or in the hands of a small group of staffers from a laboratory or R&D organization that is trying to install one of its products. Still, even here, careful analysis uncovers some linkage, technical assistance, and implementation support activities in the universities, in some of the stronger SEAs, and in LEAs and individual schools well endowed with curriculum specialists and other specialized personnel.

Overall, then, functional specialization among education R&D organizations tends to be somewhat limited, with most of these institutions encompassing several R/D&I functions. The pattern is not only one of limited functional specialization, but also limited specialization in substantive areas of R/D&I activity. Basic researchers tend to become specialists in narrowly defined research areas and subjects of investigation. However, applied researchers, developers, evaluators, disseminators, and implementation support personnel tend to be generalists within their functions -- e.g.: one year evaluating compensatory education programs; the next year examining the effectiveness of alternative dissemination strategies; the next year assessing the quality of ERIC information analysis products, etc. Within a few months time, a single large R/D&I organization within the education sector may respond to RFPs and bid on and be awarded contracts covering the whole range of functional specialties and an array of topical areas; and some of the same personnel may be assigned to work on several of these rather different contracts at the same time. Some of these organizations may also be working on contracts involving R/D&I activities in fields of health, personnel development, social welfare programs, etc. Clearly, this pattern is at considerable variance from a sector like the aviation/aerospace industry where there is highly developed specialization by function, by components (e.g.: airframes, engines, electronics), and even by R&D problem areas (e.g.: wing stress analysis).

B. A High Degree of Functional Clustering

Examination of the clustering of functions within R/D&I institutions reveals, not surprisingly, that basic research is the most specialized of the various functions and the least likely to cluster with any of the others. This is attributable to the nature of the knowledge and technology base of the basic research function; the socialization and training of its personnel; and the values, norms, and mores of the university settings in which it takes place. If we ignore basic research and consider the remaining R/D&I functions, we find several forms of both adjacent and looping clusters.

A significant amount of clustering surrounds the development function -- e.g.: applied research and development; development and dissemination; development and production of support materials for implementation/ utilization, and even development/dissemination/implementation clustering. The clustering is the outcome of conscious policy decisions of educational R/D&I managers. A less formalized version of the same kind of clustering (minus dissemination) would be represented by the creative teacher who generates an idea, gathers relevant information, develops it into a teaching strategy and instructional materials, and then uses them in her classroom.

Dissemination and implementation/utilization clustering is becoming increasingly frequent as a result of the knowledge base and personnel base that spans these two functions and as a result of the kinds of organizational arrangements that are being created by explicit and intentional policy initiatives of federal and state agencies (e.g.: training programs for dissemination and utilization specialists; state creation of ISAs to provide dissemination and technical assistance services to school districts; NIE's R&D utilization program; etc.).

Applied research and evaluation were a natural cluster during the first few years of the emergence of the evaluation research function, largely because evaluation personnel were trained as researchers; were interested in conducting research rather than evaluation; were forced into evaluation work by the operation of the laws of personnel supply and demand; and tended more often than not to piggyback research projects onto required evaluation activities. As evaluation has matured and developed an identity, methodology, and personnel base of its own, this basis for the research/ evaluation cluster has been less prominent. Still, there are several examples of well-run R&D programs where questions uncovered in the course of product or program evaluations are turned over to research personnel for further investigation oriented toward future development cycles for further product refinement (e.g.: in the development of the Individually Prescribed Instruction Program by the Learning Research and Development Center and by Research for Better Schools).

One of the newest clusterings to appear is a utilization/research cluster that may lead to maturation of a practice-oriented research specialty (as illustrated by work now in progress by the Center for New Schools to document and analyze nine LEA local problem solving projects supported by NIE).

Equally new is a utilization/development/dissemination or utilization/dissemination cluster evident in projects to identify exemplary practices, document and analyze them, use them as the basis for materials development, and disseminate these practices and materials to other potential users. The configuration is changing somewhat as more and more resources are being allocated to building linkages. Initially, this took the form of temporary collaborative arrangements and joint ventures for individual projects, joining together institutions with complementary capabilities or functional specialties. Increasingly the consortia and networks that are being proposed and experimented with are intended to be permanent, formalized interface arrangements providing either horizontal integration (linking similar institutions or organizations) or vertical integration (linking functions and/or subsystems). It will be some time, however, before we can expect to see the effects of these initiatives on the configuration of educational R/D&I institutions.

3. A Final Point: The Place of Large Corporations

One further point should be noted before we leave the topic of the structure of the R/D&I system in education. Several large corporations appear to have particularly strong positions in the grants and contracts economy of the education sector -- e.g.: American Institutes of Research, Rand Corporation, Stanford Research Institute, and Educational Testing Service. In fact, in the period FY 1973 - FY 1975, fewer than 50 organizations received the majority of NIE funding support.[93] Still, the number of R/D&I institutions receiving funds from all sources is substantial and it would seem unwarranted at this time to suggest that certain types of R/D&I in the education sector are dominated by a few large institutions in a pattern resembling the aviation/aerospace industry. However, we will be in a better position to assess this question after the NIE KPU monitoring project provides empirical data about the individual institutions that carry out educational R/D&I activities, importance for understanding the emergent configuration of educational R/D&I institutions and for developing appropriate policy initiatives and strategies for macrostructure management.

IV. GOALS, POLICIES, STRATEGIES

1. Weaknesses

Educational R/D&I has been criticized repeatedly for weaknesses in goal setting, priority determination, policy formation, and strategy development.[49, 73, 83, 103, 128] Given OE's and now NIE's status as the dominant sponsors and primary influences on educational R/D&I, it is goal setting in these agencies that must be the focus of our attention.

On the most general level, the goals of federal policy for the system have been reasonably consistent throughout the OE and NIE years. Using the current NIE formulation, these goals have been: to solve educational problems; to improve educational practice; to develop the knowledge and technology base needed for these efforts; and to develop an effective R&D system.

However, when analysis proceeds beyond broad goal statements to specific policies, programs and activities of OE and NIE (and when special note is taken of relative emphases in budget allocations), the picture that emerges is one of marked discontinuity, shifting goals and priorities, and policies and strategies that have not been entirely consistent with some of the system's goals. What has been lacking until recently has been adequate translation of broad goal statements into intermediate goals and objectives specific enough to guide priority determination, policy formation, and strategy development -- and specific enough to serve as benchmarks for measuring system performance.[126] Also lacking have been mechanisms to develop consensus on specific system goals, priorities, policies, and strategies among the various constituencies affected.

2. Historical Patterns: Changing Priorities and Decisionmakers

Historically, there has been a close relationship between the dominant system goals and priorities, on the one hand, and the primary locus of goal-setting, on the other.

A. Stage One: Research Emphasis

In the late '50s and early '60s when the dominant source of funding was the Cooperative Research Act, system priorities were determined largely by the educational research community. The locus of goal-setting was decentralized, scattered among all the various researchers and KP (knowledge production) institutions who submitted field-initiated proposals and the prominent researchers who served on review and advisory panels. In a researcher-dominated context, research was rather naturally emphasized. Development of the field's knowledge base was the goal of the system; funding educational research projects was essentially the strategy; and funds flowed primarily to the universities where educational research personnel was located.(25)

B. Stage Two:- Centralization and Short Term Emphases

This pattern changed drastically in the mid-'60s when OE funding emphases shifted from field-initiated research projects to more bureaucratically-defined, mission-oriented, programmatic R&D. The shift was gradual. When the laboratories and centers were first created, each institution defined its own mission based on the areas of specialization of its senior level personnel. Over time, however, with increasing OE use of RFPs and targetted research programs, the locus of goal-setting became highly centralized as it shifted to key OE staff members with some assistance from their advisers, whom they selected from the research and R&D communities.(25)

With the shift to a centralized locus of goal-setting, there was a marked change in goals and emphases. There was less and less concern with the

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field's knowledge base, and more and more attention to the shorter-range goal of solving immediate problems of the operating system. Those problem areas receiving the largest allocations of funds (e.g.: improving the academic achievement of low-income, minority students)[103] were defined large by social and political forces external to the education sector -- rather than by the dominant concerns of practitioners at that time, or by the needs of the field's knowledge base, or even by the state of development of the knowledge base to permit effective attack on particular problems. The bulk of resources went to the development function rather than research. The time horizons of the dominant goals were immediate and short-ranged. The emphasis was on developing packageable products. Limited attention was devoted to longer-term development of change-process strategies or resource building for enhancing R/D&I system capabilities. Concern with developing the field's knowledge and technology base had lost center stage and was not only slighted -- but many of the funding policies and strategies of this period were even inimical to this goal. Considerable resources went into building an institutional structure for a new, specialized R/D&I system -- but little of that funding was used to develop institutional capabilities for longer-term system development. Proportionally less and less of available R/D&I resources flowed to the universities, and more and more went to the regional laboratories and the proliferating non-profit and for-profit corporations geared to the marketplace of federal grants and contracts.[1, 83, 93]

C. Stage Three: NIE and Mixed Strategies

We made the point earlier that any complete picture of federal sponsorship of educational R/D&I activity requires consideration of a host of federal agencies other than NIE -- that despite NIE's role as lead agency for educational R&D, its FY 1975 budget of $74 million represents only a small portion of the total federal FY 1975 investment of $513 million. However, there is little in the published literature that is helpful for developing a clear picture of the goals, priorities, policies or strategies of these other federal sponsors. Our impressions of the contrast between current NIE emphases and earlier OE emphases may need revision after some future analyses are written of R/D&I policies of all the relevant agencies over the past decade or two. But for the present, since NIE is the lead agency for educational R&D and the system's most visible focus of policy determination, it seems useful to contrast what appear to be the dominant patterns in NIE goal-setting/policy determination for the system in the '60s.

Goal-setting and policy formation under NIE appear to present a rather different pattern -- a more collaborative mode and a mixed strategy of centralized and decentralized initiatives. Compared to the previous periods, the NIE approach appears to be less R&D-oriented and more market-oriented. Whereas the previous patterns emphasized first developing the field's knowledge base (1954-64) and then solving educational problems through R&D packaging of solutions (1964-1972), the NIE emphasis appears to be clearly on improving educational practice. R&D activities still receive a very large share of available resources, but dissemination, implementation/utilization, and building internal user system capabilities receive considerable attention in the new strategy. The federal role in the KU-oriented programs is seen as largely facilitating and coordinating, and much of the initiative in goal setting and problem definition is decentralized in the State and Local Education Agencies. Substantial sums are flowing to these State and Local Education Agencies, and several of the programs supported are oriented toward long-term capability-building goals rather than short-term product development.(86) A significant amount of emphasis in the NIE strategy has shifted from product development and product advocacy to change process advocacy and change process capability development.

Still, the older bureaucratic mode of goal setting appears to have persisted in many of those NIE funding programs oriented more toward the KP than the KU end of the KPU spectrum. The locus of goal setting in research and R&D has remained largely centralized in the hands of the NIE staff and their advisers from the field, with resultant continued dissatisfaction among the research and R&D communities about existing goals, priorities, policies, and strategies. A number of initiatives have been taken to involve researchers from a few research areas in the definition of research agendas for their fields; (e.g.:

conferences sponsored by the Basic Studies and Basic Skills groups of NIE[132]). But as yet, the research and R&D communities have not had anything like the influence of researchers in some of the scientific disciplines. Increasingly, there have been calls for a strengthening of the research and R&D communities and the development of mechanisms to permit the field to exercise leadership in defining goals and research agendas.[38] We may, then, in time see yet another metamorphosis of goal-setting and policy formation in educational R/D&I, with significant implications for R/D&I priorities, strategies, and funding programs.

V. ADMINISTRATIVE PROCESSES

As is typical of any newly developing R/D&I system, concerns for management and policy making processes have taken a low priority as compared to programmatic concerns. The dilemma is classical. Those who are most likely to initiate an innovative thrust are least likely to see the need for or pay attention to effective performance in the "mundane" problems of institutional management and the "dirty" problems of policy making. This has been the situation in educational R/D&I. Little attention was given in the past to such issues at the practitioner level, and management for educational R/D&I was not seen as a major and necessary aspect of the agenda of federal funding programs. With increasing maturation, again as is typical, concerns in these areas have begun to appear. Problems of organizational design, personnel management, project and portfolio selection, control and evaluation, cash flow management, information management, etc. have begun to plague managers and policy makers. NIE has begun on a modest scale to support some studies of management and policy making processes in R/D&I. The time would thus seem ripe for a major expansion in research and training programs devoted to upgrading the quality of management and policy making processes.

In this report, we will limit our comments to the above brief overview. In a later volume, we will provide a detailed discussion of the administrative processes function at the generic level. Analysis of the administrative process function within educational R/D&I per se, then, remains an item for analysis at some future time.

VI. PERSONNEL BASE

1. A Critical Weakness

The personnel base of the education operating system in this country is well over three million.[93] However, relatively few of the instructional and administrative personnel who staff this operating system carry out significant R/D&I activity, and we will focus our attention here on the specialized educational R/D&I personnel base.

The specialized educational R/D&I personnel base has undergone substantial development in the past decade or so. In comparison to the mid-'60s, the educational R/D&I personnel base has doubled (perhaps tripled). The best estimate was that the R/D&I system personnel base in 1964 totalled about 4,000 persons.[19] In 1974, several estimates suggest a mean figure of about 10,000 persons (estimates ranged from 8-12,000, and higher or lower estimates can be found, depending on one's definition of an educational R/D&I system).[93] Still, the personnel base of educational R/D&I may be the most critical system weakness -- and the most difficult to overcome. The literature suggests that the educational R/D&I personnel base is inadequate in sheer numbers;[19, 63, 93] is disproportionately concentrated in research, evaluation research and development;[63, 93] is critically sparse in dissemination; and almost totally absent in functional specialties that are just emerging or have yet to emerge (e.g.: need identification, acquisition, and implementation/utilization support). The field suffers particularly from the lack of an adequate supply of trained or experienced R/D&I managers, or even an appreciation of R/D&I management as a function that could benefit from specialized skills and training.[35]

2. The Sources of Personnel

By training and professional background, educational R/D&I personnel tend to come out of either the psychology/sociology statistical research tradition and the university environment[93] or out of school system positions (e.g.: teachers or administrators). With few if any training programs geared to producing R/D&I specialists (and the few that have been available geared more to the pattern of academic project research rather than programmatic development), on-the-job training has been the primary mechanism for producing personnel with appropriate skills and competencies -- an inefficient strategy at best. Some initiatives have been taken to develop training programs more suitable to the needs of educational R/D&I functioning (e.g.: dissemination and utilization training programs supported by NIE). But as yet, it is too early to detect a significant change in the character of the system's personnel base.

3. Some Seemingly Intractable Problems

The recruitment, training, and socialization of a talented personnel base for educational R/D&I will require overcoming several seemingly intractable problems; for example:

1. the low prestige of education, educational research, and educational R/D&I;

2. the orientations of most of those who come out of university settings toward advancing theory rather than improving practice; toward individualistic rather than team functioning; toward relatively homogeneous rather than heterogeneous personnel skill mixes; toward producing publications rather than products or programs; toward a professional rather than a bureaucratic style of functioning and management;[28]

3. the complexities of developing suitable training programs, given the ambiguity that surrounds the definition of work roles, requisite skills and standards for various functional specialties in the field, and the weakness of the existing knowledge base;

4. the instability of R/D&I funding;

5. the insecurity of R/D&I positions compared to tenured university posts.

4. Policy Issues

There has been much criticism of educational R/D&I for its failure to attract eminent researchers and first-rate younger talent from the disciplines. But is it possible to attract talented personnel to educational R/D&I, given the present poor quality of system outputs and the resultant inability to overcome the system's low prestige? Is it reasonable to try to intervene now in the maturation of the system's personnel base? Or, is it wiser to concentrate resources on a few key projects where the critical mass of talent already exists and impressive levels of achievement are within reach? Will a few exciting high quality R/D&I outputs do more to attract talented personnel than resource-building strategies focused on recruitment and training? High level debate on these questions would seem to be in order, leading, one would hope, to long-range planning of interrelated product development and resource-building strategies to speed system maturation.

Our knowledge of other R/D&I systems suggests that the rate at which the personnel base can be expanded varies among R/D&I system functions. In research (and to a lesser extent, development), the rate is dependent on the number and size of the existing centers of excellence (which alone can provide the training) and is a long term process. For the linkage functions (dissemination and to a lesser extent development), training programs can be developed at relatively modest levels of funding and personnel trained within a relatively short time frame. However, training in these functions will be constrained by (1) rates and levels at which users can reasonably absorb their outputs and (2) the relative lack of codification in the knowledge/technology bases. Thus, merely investing dollars in training is not always wise or effective.

VII. FUNDING

The funding of educational R/D&I suffers from five key weaknesses: insufficient diversification of sources, low levels, scattering of allocations, instability and inadequate data base about distribution of funding by functions and performer organizations.

1. Insufficient Diversification of Sources

The federal government has become the primary sponsor of educational R/D&I. A small portion of overall R/D&I funding is provided by private foundations, and an infinitesimal amount is provided by state and local governments and private industry. Several analyses of funding data are currently under way, and the precise figures may need revision when these are completed. However, for the present, we can arrive at a reasonably good picture of the level and sources of educational R/D&I funding from the best analyses available to us at this time. According to those sources, in FY 1975, total funding for educational R/D&I in this country, from all sources, fell somewhere between $605 million and $673 million (depending on what is included or excluded in a given estimate), with $619 million the most likely figure. Of this total sum, approximately 83%, i.e., $513 million, came from federal government departments or agencies.[102] The bulk of this funding is provided by the Education Division of HEW, with most HEW funds obligated through the Office of Education and the National Institute of Education. Other federal agencies providing substantial sums for educational R/D&I include the National Science Foundation and the Public Health Service (particularly the National Institutes of Health and the Office of Human Development). Additional smaller sums flow to educational R/D&I activities through the Department of Agriculture, Department of Defense, Department of Interior, State Department, Department of Labor, National Endowment for the Humanities, Smithsonian Institution, and other federal agencies.[102] The remaining sources of educational R/D&I funding include: state funds, $40 million ($30 million to $60 million); local government funds, $4 million ($2 million to $10 million); private foundations, $57 million ($57 million to $65 million); and other private sector sources, possibly (but here estimation is especially difficult) $5 million ($3 million to $25 million).[93] Greater diversification of sponsorship seems essential given the political vulnerability of educational R/D&I (and thus its funding) in a climate of limited system legitimacy and lack of confidence in the system's ability to produce a reasonable return on the taxpayer's investment. Clearly, though, substantial investment in educational R/D&I by the private sector or by state and local governments is unlikely unless imaginative new inventives are provided and bold new initiatives are taken to attract this new sponsorship.

2. Low Levels

Educational expenditures by all levels of government amount to approximately $55 billion. Appropriations to educational R/D&I account for only about 0.3% of that total.(72, 103) The inadequacy of this funding level is underscored by comparison with other sectors -- e.g.: 3.4% to 5.0% of expenditures in the industrial sector for R&D; 4.6% in the health sector; 1.1% in agriculture; and as much as 10% to 14% of the Department of Defense budget.(23, 49, 72, 103) Given the immaturity of educational R/D&I compared to these other sectors and the need for expensive capacity-building programs, the low level of funding available to support educational R/D&I becomes especially problematic.

3. Scattering of Allocations

The difficulties posed by low overall funding levels are complicated further by allocation patterns that tend to disperse what little money is available over a large number of projects rather than concentrating it sufficiently on a few. The trend in recent years has been toward greater and greater concentration of funding, as more and more projects and programs have lost funding and increasing numbers of federally supported R/D&I institutions have gone out of existence. Still, given the limited funding available and the high costs incurred by large-scale educational R/D&I programs, greater concentration would seem essential if effective programs and products are to be produced.

4. Instability

Instability of funding has been one of the most serious problems confronted by the educational R/D&I system over its brief history. The early promise of ample funding for educational R/D&I was clouded within only a few years. Funding for different types of R/D&I activities has tended to ebb and flow with frequent shifts and fluctuations in federal R/D&I priorities. Federal reliance on annual rather than longer-term funding cycles was a frequent cause of complaint in the early years of the system. While all federally funded sectors suffer to some extent from such instability, the problem has been especially critical in the education sector because of its relative immaturity.

Pleas have been made for longer-term funding commitments to permit long-range planning of complex multi-year projects, and some modifications of funding policies in this direction are apparent. Still, it would seem that greater long-term stability of funding will be needed to attract first-rate personnel and sub-contractors to educational R/D&I.

5. Inadequate Data Base About Distribution of Funding by Functions and Performer Organizations

As we noted just above, available data do suggest that scattering of allocations is one of the weaknesses of educational R/D&I. As yet, our data base is inadequate to systematically analyze the distribution of allocations. However, NIE is currently doing a survey of educational R/D&I performer organizations. When this is completed, we will be in a better position than now to estimate the relative size of actual funding allocations by functional areas of R/D&I activity. Thus, we will also be in a better position to determine the extent to which the available resources are apportioned in a manner that provides the appropriate balance among functions (taking into account the overall stage of development of the R/D&I system and any necessary corrective actions that may be needed to redress previously out of balance conditions).

Various data sources available at this time (using somewhat different definitions and classification schemes) provide rather disparate estimates of the distribution of federal funding for educational R/D&I among groupings of functional areas. For instance, a recent description of one data set for FY 1975 projects in the areas of early childhood and adolescence suggests that 80% of this funding was allocated to a category described as applied R&D; 8% to basic research; and 12%, to a group described as planning, dissemination, utilization, and evaluation.[93] Another data set (using a differently bounded data base and a different classification scheme) provides a different impression of the distribution of federal funding for educational R/D&I in FY 1975. These data suggest that knowledge production activities (defined here to include research, evaluation, and statistical activities) have received only 17% of federal funds, while 40% was allocated to a category described as applications formulations (materials development, policy formulation, demonstrations; and social experiments), and 43% to utilization (dissemination and implementation activities).[76] Still other even more recent reanalyses of these same data by NIE's R&D System Support Division staff, suggest slightly different figures, and these reanalyses are still in progress. Data from the current NIE survey of educational R/D&I performer organizations may be helpful in clarifying some of the inconsistencies.

The current survey may be particularly useful also for shedding light on questions that have arisen about the relative distribution of funding (from federal and other sources) among the various organizations that comprise the institutional base of the educational R/D&I system. NIE funding data, for instance, indicate that more than half of all NIE awards between FY 1973 and FY 1975 were made to fewer than 50 organizations.[93] It would be useful to have similar information about awards from other sponsors of educational R/D&I activity and to then explore the meaning and implications of such data for understanding the institutional configuration of the system; the location and degree of concentration of certain kinds of R/D&I functioning; the distribution of R/D&I capabilities (and implications for system capacity building); sponsor-performer relationships within the educational R/D&I system (and implications for funding/procurement policies); etc.

A substantial data base is currently being developed and analyzed to shed light on such questions, and additional studies under NIE's Education KPU Monitoring Program are in planning. As more of this information becomes available, we will be able to develop a more complete picture and a better understanding of the funding of educational R/D&I.

VIII. INFORMATION FLOW

There are three distinct information flow systems in the education sector:

1. KP information flows among educational researchers and R&D personnel generally working in organizational settings external to the user system;

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2. information flows among user system personnel;

3. information flows between external research and R&D personnel, on the one hand, and user system personnel, on the other.

All three information flows are weak and inefficient. Each has distinctive problems that impede effective communication and information flow and therefore slow:

1. the cumulative development of a high quality knowledge and technology base for the field;

2. the development and dissemination of research and R&D outputs to solve educational problems;

3. the utilization of research findings and R&D outputs in operating systems.

1. Among Educational Researchers and R/D&I Personnel

The educational research community has a well developed formal information flow system that includes annual meetings of the AERA; primary publication outlets; and secondary publications that provide syntheses and critical reviews of the literature and that provide mechanisms which facilitate information retrieval from written sources. However, scientific information exchange in education is more unstructured, random, and far less efficient than information flow in many other fields.(96, 97, 98, 99, 101) The educational research and R&D communities lack well developed informal communication mechanisms analogous to the "invisible colleges" that have been identified in some other fields of knowledge.(32, 33, 111)

Informal communication networks are critical in order for a researcher in a given research area to be familiar with work being done by others that would be potentially relevant to his own investigations. Informal networks are also critical to permit researchers to contact other researchers who can facilitate their information searches and minimize random information-seeking behavior.

Further, the absence of such informal communication networks to structure and channel information seeking behavior magnifies whatever time lags, lack of adequate abstracting and retrieval mechanisms, and other problems characterize the formal information flow system of the field.(32, 100, 101) Thus, the absence of informal networks handicaps the educational researcher.

The development of a cumulative, high quality knowledge base for the field is dependent on improving the efficiency of information flow processes -- but there are few signs of progress in this direction.

2. Within the User System

Information flow within the user system is generally retarded by various norms and patterns of functioning that tend to isolate operating system personnel from one another: e.g.: anticollaborative norms that assume the creative teacher generates ideas and teaching approaches on her own rather than using ideas and approaches developed by others; timidity about discussing classroom problems for fear of being judged inadequate; bureaucratic rather than colleagial modes of functioning that isolate the teacher in a classroom full of children and provide few opportunities for teachers to stimulate one another, exchange ideas, etc.(26, 27, 119, 125) Research suggests that most teachers do not scan the professional literature in search of ideas or solutions to problems, but instead rely on interpersonal exchanges as their main source of information.(17) Given the fact that there are relatively few opportunities for such interpersonal exchanges in most school settings, information flow is therefore minimal.

3. Between User System and Research/R&D Personnel

Information flow between user system personnel and research and R&D personnel in KP organizations external to user systems is hampered by even more serious problems -- differences in values; norms; ways of thinking and conceptualizing problems; ways of describing and bases for verifying assertions; usage patterns; little if any overlap in the journals or magazines they read (or publish in) or the professional association meetings or conferences they attend; etc.

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4. Trends and Initiatives

Some progress is being made currently to overcome the barriers to information flow within the user system and between user systems and external KP organizations. One important initiative is represented by NIE support for programs to develop internal problem-solving capabilities through organizational development and other participative renewal strategies (e.g.: the Local Problem Solving Program). Another is represented by NIE's active, interpersonal dissemination and technical assistance strategies to facilitate KPU information flows (e.g.: the Education Information Centers and the R&D Utilization Program).

However, despite AERA interest a few years ago in strengthening research communities and developing more effective communication mechanisms analogous to invisible colleges,(38) the Association has done relatively little to structure information flow in the field into more orderly patterns. There has been a vacuum of leadership in this critical area; and in the absence of any initiatives to improve information flow among education researchers, the knowledge base of the field remains weak and fragmentary and R/D&I functioning remains inefficient and relatively ineffective.

IX. INNOVATIONS

1. Widely Varying Attributes and KP/KU Requirements

Educational products and innovations vary widely in attributes and attendant KP and KU requirements. They vary in the state of the art of the relevant technologies; scale, costs, and level of R&D effort required; in type (categorized as hardware vs. software); in target functions; in demand levels and life cycles; in quality and relative advantage over competing products and practices; in testability and communicability of effects; in complexity; in compatibility with user system constraints and therefore user requirements.

Given this variability, any attempt to provide a modal description of educational products and innovations seems risky. However, to facilitate comparison with other sectors in our analysis, it seems useful to consider a number of generalizations about educational innovations that are probably valid for the overwhelming majority of products and innovations in this sector. We have noted some of these points earlier in our discussion of why the education sector is so vulnerable to environmental influences.

2. High Development Costs

Educational products and innovations that are rigorously developed and tested tend to have relatively high developmental costs. This is attributable to a large extent to the weaknesses of the existing knowledge base of the field and the resultant need for conducting an extensive amount of applied research preceding and during the development phase. Gaps in the knowledge base of the field entail more unknowns. Weaknesses in the relevant technologies entail more trial and error. The transforms between stages (from conception; to specification of design requirements; to prototype development; to development of successively refined versions of the final product) are less efficient, less predictable, more time-consuming, and more costly.

3. Product/User Reactiveness

Educational innovations tend to involve "people change" rather than installation of technology.[59, 61, 74] As such, educational innovations are harder to package, more difficult to market and get adopted, and harder to install. There is far greater reactiveness between product and users, and therefore the implementation process is more difficult and more implementation supports are needed. Product and innovation management strategies for the education sector, then, if they are to be effective, must take into account product attributes that are likely to affect user system willingness to adopt and capability to implement a given innovation. At the present time, however, integration of KU requirements into KP planning and activities appears to be the exception rather than the rule. As a consequence, externally developed R&D outputs have not been diffused widely or had notable impact on educational practice.

X. NEED IDENTIFICATION

Overall, need identification in education lacks coherence and strength.

1. Lacking: An Institutionalized Need Identification Function

Need identification is one of the functional specialties of mature R/D&I systems that is generally lacking in education. There are relatively few examples in the education sector of systematic, ongoing analyses of routinely collected data, cyclically reviewed as part of an institutionalized need identification function focused on needs assessment, capabilities assessment, and long range planning. Instead, whether we examine the process by which needed R/D&I activities are defined by KP institutions or the process by which needed R&D acquisitions are identified by KU institutions, need identification in education tends to be episodic (or, at best, attuned to the annual funding or budget cycles of R/D&I sponsors).

In further contrast to mature R/D&I systems (where need identification processes are institutionalized in specialized organizational arrangements), the loci of need identification in education tend to be scattered throughout the R&D and operating systems and their environment -- researchers, developers, R&D entrepreneurs, R/D&I sponsors, and R/D&I institutions; policymakers and administrators at the federal, state, and local level of the operating system; teachers and other operating system personnel who interact directly with students; school boards and their parent and community constituencies; and perhaps most prominent of all, the Congress, the courts, and various social movements such as civil rights, ethnic pride, feminism, etc.

Need identification in education, then, lacks formalization, and its openness to environmental influence is so great that the system lacks adequate buffers against extremely high levels of demands too varied to be met adequately.

2. Bases

Several bases of need identification are operative in education.

A. Intuitive Judgment

Intuitive judgment is the basis of what is probably the largest proportion of all need identification in the sector. There are several patterns of intuitive need identification in education: spontaneous insight; solicitation of staff or expert opinions; comparing what exists at a particular point in time in the programming of a particular R/D&I or operating system institution and what exists somewhere else.

B. Opportunistic

An additional pattern of need identification in education is basically opportunistic in nature -- the impetus comes primarily from the existence of a resource and only secondarily if at all from the existence of a problem. The availability of a resource (e.g.: funding or a new technology or an available talent pool) and its potential for use in a beneficial manner are what in fact suggests the need.

C. Data - Based

Probably the least frequent basis of need perception in education is empirical data. Two kinds of data-based need identification can be distinguished: one-time analyses of particular pieces or bodies of data, collected primarily for some other purpose but used on an ad hoc basis to identify a particular need or set of needs; and systematic, ongoing analyses of routinely collected data cyclically reviewed as part of an institutionalized need identification and long range planning function.

3. Vaugeness of Requirements

The process of translating perceived needs into innovation requirements specific enough to guide research and development is barely evident in education. More often than not, the need identification process ends with a statement no more specific than "a program to improve students' self-concepts" or "a program to raise reading achievement levels". Rarely does the need identification process in education produce a problem analysis sufficiently detailed to pinpoint either specific elements in the problematic situation (or condition in need of change) or the kind of program or product necessary to bring about desired changes.

Given the social science base of the field of education, there is a somewhat limited intellectual consensus on the one hand and a good deal of value-laden disagreement over goals and needs on the other. This puts a premium on vagueness -- i.e.: the vaguer the statement of a need, the easier it is to achieve agreement. Needless to say this complicates the problem of articulating needs in a manner that translates easily into innovation requirements.

Equally significant in its impact on needs articulation, education has an inadequate and uncertain knowledge base and an ambiguous technology. It is difficult to define problems or to know what is needed to solve them. Consequently, people have a difficult time identifying and articulating needs; thus, people also tend to generate statements that are too vague to be genuinely useful. In those atypical settings where an extensive amount of need articulation occurs, there are specialized organizational arrangements to translate vague perceptions of need into innovation requirements (e.g.: R/D&I organizations that use evaluative data on existing products as the basis of defining needs and planning R&D for future products; or R/D&I sponsors who elaborate R&D contract requirements through mechanisms like the RFP).

4. Decision Structures

Probably the greatest weakness of the need identification function in education is in the decision structures through which need statements are screened and appraised before R/D&I resources are committed. Lacking is an adequate data base against which to judge the feasibility of responding to various alternatives identified as needs for R/D&I activities -- feasibility in terms of the existing knowledge base; capabilities for meeting various needs; and marketability of various kinds of products to meet given needs. Lacking too are adequate mechanisms for bringing together the perspectives of both the KP and the KU ends of the KPU system in education to jointly define needs and priorities and jointly consider existing capabilities to meet a given need by new R/D&I activities (or alternatively, to adopt or adapt existing products or programs from the full array of available practices, programs, and products capable of meeting that need).

5. Recent Initiatives

Recent NIE initiatives have been directed toward strengthening need identification processes. The dissemination and local problem-solving programs of the Institute are basically capability-building programs: the intent is to build local capabilities for problem definition and to link user system personnel to KP resources that can be applied to solving locally defined problems. Similarly, NIE's increasing use of invitational conferences to define research agendas and needed R/D&I activities has been motivated by the desire to bring the research communities from education and the disciplines into the need identification process with maximal efficienty -- getting simultaneous input and feedback from the leaders of a given research area, and at the same time developing some consensus on priorities and disseminating these to the field (e.g.: conferences sponsored by NIE's Basic Studies and Basic Skills groups).[132] However, as yet, there is only limited evidence of overlap between the highest priority needs identified or acknowledged by practitioners and those identified and acted upon by external research and R&D organizations. Consequently, need identification at the KP and KU ends of the educational KPU system show limited integration, and the effectiveness of R/D&I functioning throughout the system is limited accordingly.

A hopeful sign is the substantial amount of effort currently going into the development and use of ongoing management information, monitoring, and assessment systems on the state and national (and to a lesser extent even LEA) levels.[31, 42, 80, 95, 118] It is still too early to expect to find significant impact from these new developments -- but clearly, as assessment systems and long range planning units get better established in the education sector, we should look for evidence of major changes in the manifestation of the need identification function in education.

XI. GENERATION/RESEARCH

1. The Focus of this Discussion

The term "research" may have a variety of connotations and meanings -- and is often used very loosely in the education sector. Thus, it is important that we first identify what "types" of "research" will be the focus of this discussion.

A. "Disciplined Inquiry"

In this discussion, we shall be concerned only with "research" in the sense of "disciplined inquiry" -- the conduct of systematic empirical investigations or the application of disciplined qualitative inquiry approaches (e.g.: historical, anthropological and political science modes of investigation) to education-related questions. Who conducts the disciplined inquiry is not at issue here -- the researchers may be those who identify themselves as educational researchers or as researchers working within a particular discipline. Within this framework, we thus include both basic (or "pure") research and applied research (i.e.: research oriented toward either product development or toward institutional and policy research concerns).

We recognize the limitations of the "pure vs. applied" usage. Still we find it helpful to think about educational research in terms of three categories:

1. basic research;
2. applied research*.
3. applied research to inform policy decisions.

We also recognize the somewhat arbitrary nature of our division between the forms of institutional and policy research that we will include here and others that we will categorize later under the concept of evaluation research.

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*In another analysis(115) we used the descriptive term "problem-focused research" rather than the more common term "applied research" to highlight the difference in focus between basic and applied research. Here, however, we will use the term "applied research" because of its common usage.

Finally, we do consider that, properly conceived and done (i.e.: as "disciplined inquiry"), evaluation is a form of research. Thus, we use the term "evaluation research" rather than "evaluation". However, because of its special nature and its usage at the utilization end of the R/D&I process, we treat evaluation research as a separate feature later.

B. Non-Systematic "Research"

We specifically exclude from our discussion of the research enterprise various quasi-research activities that are typically labelled as educational research and divert a fair amount of research funding away from disciplined inquiry, but use methods and serve purposes rather different from those of systematic research -- e.g.: school surveys, statistical surveys of the social bookkeeping variety, social action projects, dissemination and demonstration projects, and development work.

C. The Focus of This Discussion

Research is only one of several bases of innovation and product development in the education sector. Few of the dominant educational practices in schools are based on research findings. Insight, inspiration, and analysis of a relatively unsystematic sort are the bases of much conventional educational practice. Where information is sought to guide translation of ideas into practices or materials, informal interpersonal communication or more formalized library research approaches are considerably more common search strategies of the operating system than the conduct of systematic empirical investigations or application of disciplined qualitative inquiry approaches. We know relatively little about these nonscientific approaches to the generation/research function in education, though this situation may change as increasingly more attention is devoted to documentation and analysis of local problem-solving strategies in the operating system (work currently in progress by the Center for New Schools, supported by NIE).

We know considerably more about the condict of disciplined inquiry in the education sector, and it is this disciplined inquiry that has been the focus of R/D&I policy concern.

2. Issues and Problems of Educational Research

The educational research enterprise faces many of the same dilemmas as research in other fields, especially other applied social science fields. There are the universal issues of quality control -- of particular importance in education, where evaluations consistently show poor definition of educational research questions; inadequate methodological rigor; inadequate grounding in theory; and low ratings of the quality of most educational research outputs.[113, 140, 142, 144] There is also the omnipresent issue of <u>appropriate methodology</u> -- debated in education in terms of the strengths and weaknesses of experimental (or quasi-experimental) vs. the less controlled designs in the field settings in which most educational research is conducted.[10, 53, 135] A related issue concerns the inappropriate application of various statistical techniques in data analysis.

Several of the generic research issues that cut across all social science fields (and perhaps other sectors as well) are <u>particularly</u> pronounced in education because of the nature of the field's knowledge base, the nature of the demands made on the educational research community by external environmental forces, and the deep strains in relationships between researchers and practitioners. Instances of these generic issues that take on particular salience in education are: how to produce interdisciplinary cooperation; how to determine priorities between basic and applied research; and how to protect subjects and operational settings from unwarranted interference by researchers.

A. How to Produce Interdisciplinary Cooperation

Education is a conjunctive domain of knowledge -- i.e.: a field that focuses the perspectives of several disciplines on understanding and solving certain social problems.[133] Since as many as twelve (or more) disciplines converge on inquiry in education, interdisciplinary cooperation and cooperation between educational researchers and researchers in the other disciplines become all the more important -- but no less easy to attain.

B. How to Determine Priorities Between Basic and Applied Research

The debate between/basic and applied researchers in education is phrased in terms of the weaknesses of the field's knowledge base (how little or how much we know at this time to guide program or product development) vs. the immediacy of the problems in need of solution. Thus arguments can be made in support of basic research at the expense of applied research -- for example: the contention that R&D programs at this time are premature and ill-conceived because the basic knowledge base is inadequate; the argument that applied work is ineffective in solving problems because it is framed in terms of existing conceptions that are inadequate and will remain so until basic research produces major breakthroughs that affect the way we think about problems as well as the knowledge and technology we apply to them. However, other persuasive arguments can also be made for applied research at the expense of basic research -- for example: the argument that we already know a great deal that is useful for solving pressing problems that cannot await maturation of the field's basic knowledge base; or that effective solutions can be developed if the available knowledge base is effectively transformed and structured in a manner that facilitates application.

Work now in progress will soon provide us with a better picture of how much support comes from which federal agencies (and other sources) for basic and applied research (e.g.: analyses currently being conducted by staff members of NIE's R&D System Support Division) and will place us in a better position to make judgments of the adequacy of the level of funding for system development. Numerous criticisms have been made of basic research funding in particular --that it has been relatively small in scale (and overwhelmed by proposals relative to available funds); has not been designed in accord with any overall basic research strategy; and has lacked either continuity or high visibility.

There were many high hopes for NIE in connection with basic research in the months prior to its creation -- but NIE has not become the think tank of eminent scholars that NIE proponents envisioned and argued for. Instead, funding problems have forced cutbacks in the small basic studies unit within NIE; allocations for basic research grants have remained relatively small; and earlier initiatives to strengthen basic research (e.g.: the four-year funding of COBRE, the Committee on Basic Research in Education) have not been continued.

The COBRE project was of particular importance. It had an eminent organizational setting (the National Academy of Education and the National Academy of Sciences - National Research Council). Eminent scholars served on the Committee. Its task was "to identify problems to be attacked by basic research in education and to develop and try out plans and procedures for stimulating and supporting such research." It had moderate success in attracting both established and younger scholars from the social sciences to basic research in education. Still, it was discontinued.(12, 20, 44)

C. Ethical Issues

Ethical issues surrounding relationships between researchers and human subjects take on added meaning in education where the human subjects are often children and where relationships between researchers and practitioners are often strained. In educational research settings, the need to protect subjects from harmful effects of experimental treatments or from invasion of their privacy is a very important issue. These direct ethical issues raise further issues about the amount of control a researcher can have over the conduct of his own inquiry -- e.g.: the role of the practitioner in defining the problem to be investigated; the amount of manipulation of "treatments" to be permitted in an operational field setting; the needs of researchers for a stable program stimulus vs. the needs of program personnel to keep changing their program in terms of changing needs and understandings of what they are doing.

3. The Changing Character of the Educational Research Community

A. Initially: A University Base

In addition to these various research issues, there are a host of new issues that have emerged out of the changing character of the educational research enterprise. Until the mid-'60s educational research was an activity carried out by a relatively small number of individual researchers who were based in the universities; operated with a great deal of autonomy in defining problems and conducting investigations; devoted a small proportion of their time to research; were oriented primarily to publishing research findings that might add to our understanding and knowledge about educational phenomena; and were regulated primarily by a peer group review system that allocated rewards primarily in the form of prestige and recognition within the scientific community.

B. New Institutional Arrangements

Developments of the past decade and a half have transformed educational research. The educational research community has grown rapidly in numbers and in diversified institutional bases.[88, 93] Although almost all basic research is still carried out in the universities and some applied work is done there as well, non-profit and for-profit research corporations have emerged as a strong competitive force in securing applied research contracts from governmental agencies.[1, 83, 93] Consequently, more and more of this research is being done outside the universities, with serious consequences for research training; for information flow and the cumulative development of the field's knowledge and technology base; and for the manner in which (and the extent to which) research findings get to be disseminated and utilized. The new institutional arrangements for the conduct of research have turned research into a full-time pursuit for a large portion of the research community. Of even greater consequence, these new arrangements have had a significant impact on the nature of educational research and the educational research community. These new arrangements have produced new patterns of research functioning (e.g.: research teams rather than individual researchers). There are new modes of research management and new constraints on researchers -- i.e.: bureaucratic, mission-oriented research management that limits the individual researcher's autonomy in both defining research problems and conducting inquiries.[25] There are new research subcultures with wholly new systems of rewards and controls that weaken the impact of the disciplines on the conduct of inquiry -- e.g.: political and bureaucratic norms are competing with and (for many) replacing professional norms; political influence and economic incentives are replacing scientific recognition as rewards; and agency acceptance and utilization of research findings are replacing peer review of scientific quality as the dominant controls.(28)

C. New Kinds of Accountability Issues

The new prominence of educational research, and the amount of public funds flowing to it, have posed new kinds of accountability issues that may be harder for researchers in the education sector to resolve than researchers in other sectors which have stronger knowledge and technology bases. The Congress has been demanding public accountability for an immediate payoff from its investment in educational research -- without any realistic appreciation of the extended time frame needed to produce results in research in general and in educational research in particular. Thus, we find a "Catch - 22" type of situation. On the one hand, to obtain funding, researchers must provide some promise of a payoff -- regardless of the fact that research by definition involves a not insignificant degree of uncertainty. On the other hand, to make promises which cannot be fulfilled may result in the researcher being funded -- but even more importantly, such unfulfilled promises lead inevitably to public disillusionment and a worsening of the political environment of the research enterprise. The proper stance for educational researchers to take in relation to government agencies, and the kinds of research outputs they should provide (i.e.: solutions, approaches to defining problems and thinking about solutions, or information about the likely or obtained effects of alternative solutions under consideration by policymakers) -- these are matters of serious debate among educational researchers and social scientists in general.(22, 79, 110)

4. The Future

Despite frequent calls in recent years for a strengthening of the educational research community and more field-based initiatives to structure the national research agenda for education,(38) the educational research community remains

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diffuse, politically weak, and largely reactive to federal initiatives designed by government bureaucrats who are generally not members of the research community. We see relatively little evidence that this situation will change in the near future -- certainly not without NIE support and initiatives.

The strengthening of the educational research community in the future may well depend on collaboration among the leadership of the research community and the key federal agencies and other major sponsors of educational research, with initiative perhaps remaining still with the federal agencies. Our analysis of what is needed is based on consideration of the somewhat distinctive requirements of basic and applied research and the current state of development of the institutional and personnel bases for conduction of the basic and applied research functions.

In thinking about the future of educational research, we will need to review our understanding of the basis upon which it may be assessed and of its current status. From these we may suggest key needs for the future development of the educational research function. We will do this separately for basic and applied research.

A. Basic Research

Assessment Basis

In assessing basic research for education, it is important to recall the interdisciplinary nature of educational research. On the one hand, we said that there is basic research being performed in several disciplines (e.g., psychology, sociology) which will be relevant to education. However, education is a subsidiary concern of these other disciplines. On the other hand, consideration has also been given to basic research which is done within the field of education per se and which is performed by researchers trained in and committed primarily to education as a field of study. It is this latter focus which is our primary concern here because of the importance of having a basic research function whose primary and ongoing focus and commitment is on the field of education per se -- while at the same time recognizing and utilizing important and relevant basic research in other fields.

As basic research is an uncertain, unpredictable and highly creative uncertaking, it is very sensitive to threats to its climate and to the quality and stability of support and funding and is highly dependent on its roots in its fundamental disciplines. Its outputs are knowledge and stimulation and it is only generally in the long term that we can assess its practical contribution. And, given its inherent uncertainties it becomes hazardous to attempt to predict the areas in which such outcomes will occur. But without it the well of new thinking frequently runs dry. It is therefore vital that a healthy and mature R/D&I system will have developed and maintained a substantial high quality basic research component.

Such a component cannot be built quickly. The rate at which quality basic research can be expanded is limited by the size and quality of its existing centers of excellence (which may range from a single outstanding researcher to a team of such researchers). To pump more funding into this endeavor than such centers can usefully absorb can only lead to waste and disappointment. Future growth is (and will be) limited by past investments in creating and supporting a central core of basic research having many centers of excellence. The major problem of basic research within education as a field of study per se has been as we noted in the very weakness of this central core.

Assessment of the basic research function will need then to be based on:

1. The size and quality (based on the reputation of institutions and personnel) of the central core of the basic research function -- most specifically on the size, growth and stability patterns of identified centers of excellence. An important indicator will be the ability to attract and hold top flight researchers.

2. The number of new centers of excellence seeded and taking root over successive (rolling) 3-5 year periods.

3. A measure of the supportiveness of the climate - in terms of funding growth and stability over several year periods.

4. Measures of the quality of the linkage to and reputation of basic research in education and its more fundamental root disciplines (e.g.: psychology, sociology, etc.).

5. Over long (10-20 year) time spans, an assessment of major substantive contributions to knowledge coming from educational basic research.

Current Status

We have seen that basic research in education is generally to be found in two types of settings. That located in schools of education (frequently in such disciplines as educational psychology and sociology) boasts few centers of excellence and much mediocrity. A different picture emerged from viewing the research carried on in discipline based university departments such as psychology and sociology. Excellence and valuable contributions to knowledge are to be found, but what has been lacking here has been a primary and continuous commitment to education. The interdisciplinary character of educational research has added to the diffuseness by making communications and information retrieval (from the large variety of publication sources) very difficult. Altogether, this has added up to an educational basic research community that has been to date unstable and amorphous. It makes system building in this area a major requirement and a critical consideration in funding programs.

At the same time, the general climate for basic research in education as for other (especially social) areas of basic research has been far from supportive. This negative climate has been particularly intense for education which has been hard put to point to more than a handful of significant developments that are traceable to basic research. The low prestige with the general public and with Congress and the associated unreliable funding have made it hard to attract strong talent and this has acted as a major constraint on building the central core. As regards funding, it is vital to note that there are many agencies which fund basic research in education. Indeed, the National Institute of Education (which has been assigned "lead" responsibility for educational research and development) has been a relatively minor contributor to the total funding going to basic research, especially in comparison with such an agency as NIH.

Key Needs

In light of the above summary analysis of the distinctive requirements of basic research and the current state of development of this function in education, the key need would seem to be for a consistent, continuous, stable process of system building. This would include:

1. identifying existing centers of excellence;

2. facilitating the establishment of additional centers of excellence;

3. facilitating the growth of these centers, existing and new;

4. facilitating improved information exchange and retrieval mechanisms;

5. providing stable, long term funding.

B. Applied Research

Assessment Basis

It is important to be reminded that applied research is research and shares with basic research a high level of uncertainty and unpredictability. Thus, researchers in particular treat applied research in a basic research mode. But it is also targetted research. Thus, funders and users often assume it to have the level of certainty and shortness of time line more appropriately associated with development. This deceptiveness and the consequent inherent tension makes applied research subject to considerable instability, misdirection and mismanagement, and consequent misdirected assessment.

Researchers frequently redefine and bend applied research into basic research modes. In particular, they often attempt to undertake projects on smaller scales than are required by the nature of the problems, which often require the efforts of large-scale interdisciplinary and empirically based team programs. This syndrome is often combined with attempts to oversell the timing, probability and impact of outcomes in order to obtain funding. This often succeeds with funders simply because applied research projects do appear to have practical, attainable outcomes. All of this creates an environment that tends to be unattractive to many of the best researchers.

On the other side, users and funders, having been persuaded to fund such programs because of these very expectations of near-time benefits, become frustrated by not only the lack of delivery but also by the shifting targets, time and cost patterns which are inherent in the uncertain research process.

Another important dimension of this tension lies in the problem of need identification. On the one hand, the objective is to work on important and timely problems that require solution, and this tends to be the prime inducement for the users and funders. On the other hand, a researcher is required to maintain the criteria of researchability -- criteria that often significantly limit the utility of the project from the user perspective. This as well as the previously mentioned problems of tension become magnified when one recognizes that the cost and scale of applied research tend to run orders of magnitude higher than what is typical of basic research.

Assessment must therefore be based on judgments of:

1. The quality and appropriateness of the institutions performing this function:

   Are they capable of mounting the required large scale interdisciplinary efforts?

   Are they attracting and keeping top quality applied researchers?

   Are their programs and projects considered to be of high quality, important to practice and on truly researchable problems?

2. Whether applied research is emerging as a definable entity, differentiated from basic research and development.

3. After a time lag that reflects several years of sustained system building, an evaluation of the rate and impact of outputs.

4. The climate for applied research in terms of both support patterns and receptivity to its outputs.

Current Status

Most of the research that is carried on in education appears to be what might loosely be defined as the applied type, much of it unfunded and small-scale. The volume of studies produced may indeed by large -- but being of this small-scale, scattered and fragmented quality, these have been subject to many questions of quality. It is evident (as mentioned earlier) that there is substantial lack of differentiation in education between what can truly be classified as research and various other activities (e.g.: demonstration projects, social bookkeeping, etc.); great weakness in defining researchable problems; considerable fuzziness in differentiating applied research from basic research and development; and the previously mentioned tendency to oversell such projects.

As we noted earlier, applied research in education is largely carried on in two types of institutional settings: universities and large-scale R&D institutions in the private and quasi-public sectors.

Where this work has gone on in universities, there has been a tendency to perform applied research in a basic research mode. This is not surprising given the socialization and prior training of university researchers and the social and publication pressures under which they operate. Generally, universities find it difficult to assemble the minimum critical mass of effort needed to undertake large-scale applied research projects. As a consequence, they have tended to scale such projects down and/or to assemble ad hoc teams that lack long-range stability. With this has come the unfortunate tendency for researchers to move in and out of this part of the field which has mitigated against system-building requirements.

Large scale R&D organizations should have been, and to some degree have been, more suitable sites for such programs. However, two important problems have limited their potential success. Firstly, most of these R&D organizations have not been able to promise a stable career path to researchers, thereby greatly limiting their ability to attract and hold first-rate researchers. Secondly, federal funding practices in the late '60s shifted the character of many of these institutions away from applied research and reshaped them into development organizations in accord with federal priorities at that time for product-centered impact strategies.

As a consequence of the above conditions, education has in fact seen very little applied research. Therefore, this has to be seen as an area that needs to be put together at this time in its own terms and not be thought of as a form of advanced development or downstream basic research.

A number of other problems in educational applied research were previously implied but require further explication. The climate for such research has been perhaps even more negative than that described above for basic research. This has been so precisely because it seemed to hold out more promise of impact and raised expectations than could have been satisfied -- given the inherent time frame and the weak state of the area. Relatedly, need identification, which had been researcher-driven up through the mid-'60s, became system-driven by users and funders in an overreaction to this state of affairs. As with basic research, funding has been realtively limited.

Key Needs

Applied research in education, then, must be seen in a system-building mode.

1. It will be essential to locate those centers of excellence capable of performing large-scale applied research.

2. Such institutions will need to be provided with the kind of long-term stable funding that will permit them to attract and retain top-flight staffs of researchers.

3. It will also be vital for the lead educational funding agencies to help practitioners and the Congress understand the nature and requirements of applied research to:

   understand that project selection requires the determination of what is researchable as well as what is important;

   recognize that the present lack of capacity demands a period of institution-building before the promise of the area can begin to be fulfilled;

   and understand that such institution-building will require an ongoing and long-term commitment.

XII. DEVELOPMENT

As described in the literature, the development function in education adheres strictly to the engineering model of development used in industry. But the development function described in the literature represents only a portion of all development work that is done in the education sector -- the development mode as it is carried out in pursuance of government contracts, primarily in regional laboratories and in some of the non-profit and for-profit research and R&D corporations. If we accept a broader and less rigorous definition of development work, then we must also include several other models of the development function as this is carried out by classroom teachers, by curriculum specialists in SEAs, ISAs and LEAs, by textbook publishers, and in university-based curriculum projects.

1. Development as an Institutionalized Functional Specialty (Using the Rigorous Development Model)

Considering first the rigorous definition of the development function as an institutionalized specialty that is carried out by specialized personnel in specialized institutions or organizational units, development activities are systematic and sequential. Development moves in a smooth progression from prototype design that is the end product of the applied research phase of R/D&I; to product or program development in accordance with detailed specifications; to evaluation of small field tests; to revisions; to larger field tests; to more revisions; to an additional field test; etc. -- until the product performs in accord with the prespecified performance objectives. Products go through successive generations of revisions, each a closer and closer approximation to the performance specifications. Revisions are based on empirical field test data that are gathered systematically and analyzed rigorously. The evaluation data provide the potential user with precise information about the outcome or effects to be expected from use of the product under specified implementation conditions.[60]

Development projects implemented in accord with this model tend to be large-scale and expensive; involve large personnel base pools and heterogenous skill mixes; and involve extensive cooperation between the R&D organizations developing the products and the school systems agreeing to serve as field test sites. The products themselves are often complex, consisting of many and varied modules or components, and often several forms of media as well as printed materials. The management of these complex development projects is often highly formalized, using flow charts and sophisticated management tools.[60, 66, 116]

There may be some variations in pattern depending on the nature of the R&D outcome being developed -- e.g.: products vs. change processes. However, the issues of concern to managers tend to be consistent: How much research is needed prior to the development work? How much research can proceed parallel to the development work? At what point is the product sufficiently developed to permit initial field testing? At what point is the product been tested sufficiently to permit dissemination? What dissemination, marketing, and implementation factors need to be considered throughout the design and development phase? At what point does the responsibility of the developer end: development? dissemination? installation? utilization and maintenance?(7)

2. Development in the Education Sector

These issues are to some extent common to the development function in all sectors, but they take on particular significance in the education sector. The weakness of the knowledge and technology base of the field makes it more difficult to translate performance specifications into effective products. Outcomes are far less predictable given the reactiveness of the user setting and limited technical capability of user personnel to implement complex innovations without substantial implementation supports. Consequently, development work in education requires a far greater investment of time and money in the research and evaluation components of the development process, making development costs high relative to practical payoffs -- a problem of particular importance considering the negative political climate in which educational R&D appropriations are made.

The rigorous model of the development function as it is used in the regional laboratories can be contrasted to the more traditional approaches to the design and development of instructional strategies and materials -- as these activities have been carried out by classroom teachers; by curriculum specialists in the SEAs, LEAs, and the universities; by publishers; and by the university scholars who have on occasion participated in efforts to improve K-12 level curricula and instructional materials in their areas of specialization.

The development approach used in these settings tends to be intuitive rather than data-based or grounded in theory. The focus of attention is generally on the content to be conveyed rather than conception of how students learn or how teachers go about providing instruction. Field testing is non-existent or minimal. Development costs are relatively low. The personnel involved are relatively few (e.g.: one teacher, a few scholars or curriculum specialists, etc.); and whatever skill mixes are present in a development team tend to be relatively homogenous. Management is generally informal and highly flexible. Where textbooks or materials packages are being developed for large-scale, nationwide dissemination, an effort is usually made to include implementation supports in the form of teachers' guides, tests, etc. Where materials are developed locally for use by a single teacher or a group of teachers in a single school or district, far less of the implementation process is committed to print or media presentation; the state of "development" of the materials or strategies for use outside this small group remains inadequate; and either the locally developed innovations are not disseminated at all or they are disseminated but have minimal success elsewhere because development work was not carried far enough to permit the materials to be implemented easily and effectively by others.

3. Changing Patterns of Federal Support for Educational Development

The rigorous development model is likely to permit more effective implementation of developed products. However, consideration must also be given to the high costs of rigorous development work, the relatively limited utilization of externally developed R&D products to date, and the extensive amount of local innovation that exists. Thus, federal policymakers are giving increasing attention to internal user system development resources -- building internal innovation capabilities; linking internal sources of innovation to external resources for documenting and analyzing local innovations and developing materials that could be used to assist other school systems in implementing these locally developed programs and practices (e.g.: OE programs in support of SEA efforts to identify, validate, and package exemplary practices; NIE-supported programs to build SEA dissemination capabilities and LEA problem solving capabilities). The bulk of federal development resources appear still to be awarded to external R&D organizations that use the engineering model. (We will be in a better position to verify this impression after data from NIE's current survey of KPU organizations are gathered and analyzed.) However, it seems possible that this balance may change in time. If this does happen, the character of the development function (as this is generally understood in the educational R/D&I community) may undergo considerable change, and with it the institutional bases, the personnel base, and especially the technology of the development function.

4. The Future

If the development function in education were mature, we would expect to find a large supply of high quality outputs that are responsive to user needs. Since most available outputs of educational development appear to be weak in both quality and responsiveness, future strategies for strengthening this function must be based on consideration of the essential requirements of the development function and the major weaknesses of each of the two predominant modes of development work in the education field.

As we noted in the discussion of the future of educational research, to think about the future of the development function in education, we will need to review our understanding of the basis upon which the educational development function may be assessed and of its current state. From these we may suggest key needs for the future of the development function in education.

Assessment Basis

As we have noted critical in the assessment of the development component of an R/D&I system is the recognition of the centrality of its linkages to the user, to production and to the state of art in development. Development has a relatively more predictable and shorter time horizon process as compared to the research functions. It aims to convert knowledge into user-ready products, products which may (or may not) need to pass through a distinct production phase before they can be disseminated or distributed. With the linkage to the user being so critical, so is the requirement for need identification -- a step that is difficult to perform, but one that must be done well and often in an ongoing manner during the development process (where complete identification is not feasible -- as in many areas of social development) if the product selected for development is to be on target.

Development is also highly dependent on the quality of its linkage to the state of the art and on the skills and motivation with which products are designed so as to be capable of production and dissemination. This determines the effectiveness and viability of the product.

Since development is frequently carried out in specialized development organizations it is highly dependent on the quality of such institutions and their personnel and most particularly on their experience. It is important to differentiate the concept of excellence in development from that used in research. In development excellence is measured by being cost/effective, timely and opportunistic. With such criteria, experience (individual and organizational) and thoroughness (ability to do the whole job) are often more important than brilliance. Where development is carried out in a user setting, then assessment must be concerned with the extent of wider dissemination of the products or processes developed.

Thus, the critical bases for assessment are:

1. Quality of linkages to:

   - users
   - production
   - development state of the art.

   Measures of such linkages are hard to define and obtain, depending as they do upon quality, frequency and form of interaction. They will likely be qualitative in nature, and "observable" more in their absence in terms of problems generated, than in their presence.

   A specific manifestation of this linkage will be in the quality of need identification, to be measured indirectly by the relevance of development outputs for practice, and by the scope and effectiveness of feedforward activity from users to developers.

2. Number and effectiveness of large-scale development organizations. Effectiveness here would be measurable in terms of extent of adopted products and some qualitative assessment of impact (actual and potential).

3. Extent of dissemination of practice-based developments.

4. The number and quality of products developed from the whole R/D&I system and their overall (portfolio) effect. Quality would again have to be measured by usage based criteria although the locus of quality control would be a design variable.

Current Status

As we have discussed, educational development is plagued by a weak knowledge base. The quality of information is poor, very little has been codified. As such, quality control is a central requirement, which has only recently begun to receive serious attention but which is still relatively poorly developed and its enforcement a matter of some diffuseness as to locus of responsibility. With limited ability to depend on quality control in the field, funders and program managers may need to build quality control checkpoints into staged development procurements, a procedure that demands closer involvement and orchestration between key funding agencies and the field than has been typical to date.

We noted earlier that there are two distinctive modes of development work in education:

a. development work that adheres to the rigorous development model and tends to go on in specialized development organizations;

b. more conventional, intuitive modes of development that tend to be carried on as part-time activities in practice-based settings.

At its best specialized development organizations represent a strong element in educational R&D system capacity. There are a few such well staffed and experienced development organizations and their existence is an important indicator of the system building that has gone on. More often, however, the institutions and personnel involved in development do not come up to these required standards. Even the best of these organizations tend to suffer from isolation from practice, making dissemination and implementation problematical. This may be one of the causes of the limited utilization of R&D based products, a shortcoming that is tending to threaten the viability of this type of institution. There may be a critical need in development not to increase the level of effort overall (there is an inventory of more than half a million R&D products that are available for sorting, tailoring, packaging and dissemination) but rather for a shift of emphasis so as to build up more of the strong high quality development organizations with whom the government can contract and to ensure their closer linkage to practice.

The second basic mode of development in education (practice-based) does not suffer (obviously) from poor linkage to the user. It does suffer, however, from inefficiency, lack of sophisticated skills, poor documentation of its achievements, difficulties with packaging, and from enormous problems in achieving wider dissemination and diffusion. State initiatives have become particularly significant in recent years in identifying, packaging and disseminating exemplary practices and programs developed by local school systems. The verdict is not in as to whether this mode can become a source for wider application (beyond the local development site). Meanwhile, further research on this mode is required as well as support for efforts to supplement and expand local capabilities possibly through increased linkage and collaboration between practice based development and specialized development organizations.

In the area of project selection the emphasis to date has been on a project-by-project selection process. Missing has been the capacity in the system to consider critical portfolio effects. These could involve decisions to target and concentrate development programs so as to achieve synergistic benefits, staging and sequencing strategies that minimize user disruption and uncertainty, cooperative ventures across agencies, etc. Particularly important may be the need to develop skills in commercialization so as to make better decisions with respect to what to place with which elements of the private sector and when.

Key Needs

With the above in mind, the following would appear to be key needs for the educational development function, particularly with reference to the role of key funding agencies.

1. Work with the field to build up the explicit designing-in of quality control functions into funded development programs - possibly including staged programs with quality control check-points.

2. Shift support emphasis to favor those high quality specialized development organizations that show a pattern of being responsive to practice needs and to technical opportunity.

3. Work with SEAs and LEAs to determine the most cost effective ways of identifying and disseminating practice based development products.

4. Study and experiment with strategies designed to improve the interface between the government funded development organizations and commercial firms -- including development of criteria for what should be handled how and by whom.

5. Development of program planning and project selection methods by key funding agencies that give explicit consideration to portfolio effects.

6. Explicit programs designed to achieve inter-agency cooperation for development activities.

7. Study and experimentation with strategies designed to improve the interface between the government funded development organizations and commercial firms --- including development of criteria for what should be handled how and by whom.

XIII. PRODUCTION

Production issues are of minimal concern at this point in the historical development of the educational R/D&I system. As we use the term, the production function is restricted simply to the reproduction or manufacturing in quantity of a fully developed and tested item. All design and development work is subsumed under the research, development, and evaluation research functions. For the most part, production in the education sector takes place in the subordinate system of institutions that provide support services to the educational R/D&I system -- publishers, film production companies, manufacturers of hardware and equipment, etc. These production institutions tend to be sector-spanning in nature, and none of the production issues that come into play appear to be sector-specific to education.

Production issues are of relatively low priority in the education sector. The overwhelming majority of educational products and R/D&I outputs tend to be software rather than hardware; the predominant medium is print; and the key issues of performance and reliability have less to do with possible breakdowns in the production function than with weaknesses in the development function or the implementation process. Commercial publishers generally strive for a high quality print product using costly materials and production techniques. On the other hand, the gloss of commercial publications is generally absent from the outputs of R/D&I organizations. To some significant degree, this appears to be a consequence of clearly articulated policy decisions of educational R/D&I sponsors and contractors. Educational R/D&I decision makers have opted consciously for allocating maximal resources to the research, design, development, and evaluation of the substance of the materials, and the barest minimum to production -- just enough to insure that a sufficient quantity of usable materials can be distributed to operating systems.(7)

Some recent initiatives have been taken to develop collaborative relationships between R/D&I organizations with strong development capabilities and commercial publishers who can add high quality production capabilities (e.g.: arrangements between Appleton Century Crofts and the developers of Individually Prescribed Instruction). However, these arrangements are relatively few in number; the linkages are tentative and experimental; and as yet the production function is barely visible in the configuration of educational R/D&I.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

The linkage functions of marketing/distribution/dissemination/diffusion have always been among the weakest components of educational R/D&I, and have only recently become the focus of federal and state R/D&I policies. Each of these functions has had a number of traditional meanings, each with its own set of institutions, channels, and characteristic activities. New conceptions of these linkage functions are gaining wider acceptance, and new institutions, channels, and activities are appearing to operationalize the newer approaches.

1. An Emphasis on Information Flow

Until recently, the dissemination function has been concerned primarily with the flow of information -- the outputs of research -- rather than the marketing and distribution of packaged R&D products. Further, dissemination strategies have been so passive and uncoordinated that the burden of effort in retrieval was on the researchers and practitioners seeking information. The characteristic channels have been publications -- reports of research findings in technical reports to sponsors or in scholarly journal articles targetted at the research community; or in non-technical form in articles appearing in the magazines and newspapers read by practitioners and laymen. Informal, interpersonal information exchanges took place at professional association meetings of researchers and at other meetings of practitioners, and at occasional conferences, seminars, or workshops. The universities and teacher-training institutions also performed a key role in passing on a field's knowledge base in pre-service training programs, or in updating knowledge and skills through in-service training. For the most part, however, this pattern involved dissemination of individual pieces of information with a potential for application rather than packaged information products designed to produce changes in practice.

The exceptions here were the publishers and equipment manufacturers who packaged information or technological products into immediately usable forms and had well developed marketing and distribution operations to get their products into the hands of practitioners with a minimum of effort on the part of user system personnel.

2. Dissemination in the '60s: The Impact of Federal Policies

Federal R/D&I policies in the '60s added several new dimensions to the then existing modes of dissemination. The crowning glory of the information dissemination policy was the massive ERIC system created by OE to acquire, store, abstract, and provide easy computerized retrieval of sources from the extensive fugitive literature of the education sector. ERIC also provided publications that announced acquisitions to the field and therefore was expected to make them more visible; indexed the journal literature of the field as well as the fugitive literature stored in the ERIC collection; and provided several hundred information analysis products that synthesized information in selected topical areas. (Professional associations of both researchers and practitioners also became active in the '60s in producing targetted information analysis products or synthesis of the available knowledge and technology base in specific research areas -- e.g., the National Education Association's What Research Says to the Teacher pamphlet series; two editions of the Handbook on Research in Teaching;(47, 138) and four editions of the annual Review of Research in Education.(68, 69, 70, 120)) However, ERIC has been repeatedly criticized as geared largely to the needs of researchers rather than practitioners. More recently, in response to practitioner needs, ERIC acquisition programs have included efforts focused on storage and retrieval of curriculum packages and other development products (e.g.: product information packages). As yet, ERIC appears to be used little by practitioners.

The network of institutions created by the federal government in the '60s included organizations charged with responsibility for acquiring and disseminating instructional materials in given areas (e.g.: The Instructional Materials Centers) and organizations designed to demonstrate and disseminate exemplary local practices (the ESEA Title III demonstration centers). Dissemination of the R&D outputs of the laboratories and centers was considered a major function of these organizations. Categorical programs (e.g.: ESEA Title I, Upward Bound, programs for the handicapped, vocational/career education) have always included dissemination components. Additionally, various referral organizations (e.g.: the National Referral Center and Phi Delta Kappa's School Research Information Service) and other more active and interactive approaches to dissemination (e.g.: education information centers with education extension agents[29, 90, 127]) also began to appear in the '60s. Still, despite all these initiatives, by the early '70s it seemed clear that the outputs of educational research and R&D were not reaching the user system to any significant degree or having clearly visible impact on improving educational practice.

3. Federal Dissemination Programs

Current federal dissemination programs have been built on many of the initiatives of the '60s, but carry them further and change the focus of federal dissemination strategies. Historically, the overall federal strategy could be characterized as:

1. initially one of laissez-faire[112] (prior to the mid-'60s and in the initial conception of ERIC as a passive information repository);

2. then a strategy of product advocacy[112] (the Instructional Materials Centers, laboratories and centers, and Title III demonstration centers advocating the use of particular products or programs they selected or developed);

3. and finally, strategies of

   a. coordination of existing discrete efforts,[40, 65] and

   b. change process advocacy,[112] replacing advocacy of particular programs and products with informational and capability building approaches: providing extensive amounts of (and easy access to) information on the full array of available products, programs, and practices to meet given needs; providing easy access to education extension agents in local education information centers; developing users' capability for evaluating, adapting and implementing the products of their choice. (29, 83, 94)

The federal role is seen as one of facilitating, coordinating, and providing start-up funds to mobilize state and local dissemination resources. The focus is on building networks that bring together and strengthen the dissemination resources of existing organizations that carry out dissemination activities, especially the SEAs. (89)

The approaches that have been funded tend to be active and interpersonal -- e.g.: working through educational extension agents, local education information centers, networks of consultants, and interactive computerized retrieval mechanisms. Educational extension agents and other personnel working in local districts are linked to centralized resources and specialists; information needs of local users are determined; information and materials required to meet these needs are transformed into packages tailored to the user's needs and constraints; and followup supports and feedback mechanisms are built into the overall design. (29, 127) To date, these systems have been developed extensively in relatively few states, though the number and scope of these programs are expanding under NIE dissemination capacity building grants to states. Clearly, this active, interpersonal, user-oriented and field-based networking strategy is the direction in which educational dissemination in the U.S. is moving at this time.

. The Current State of Dissemination

Clearly, the institutional base of the dissemination function has undergone extensive development in recent years. Considerably more expansion is likely if NIE's Research and Development Exchange program (currently in the planning stages) becomes operational. Nonetheless, it will be some time before can expect to find substantial impact in the form of widespread improvement in educational practice. There have been serious efforts to synthesize the theoretical knowledge base of the function,[55, 58] but the translation of this knowledge base into usable strategies with known effects is only beginning. The dissemination specialty is only now beginning to appear and is clearly inadequate for the scope of existing programs such as the Research and Development Exchange program noted above. Most of those currently carrying out dissemination activities appear to be practitioners by training. They are proceeding intuitively and learning the dissemination field on the job. Few programs are available to train dissemination specialists.

Until recently, the linkage functions of marketing/distribution/dissemination/diffusion have been among the critical gaps in the educational R/D&I structure. There are hopeful signs that dissemination and diffusion are maturing. But despite all the discussion in recent years of bringing a marketing approach to education,[5,62] and despite the current focus on user needs and user viewpoints,[83, 85, 87, 94] the marketing perspective is almost totally absent and may in fact have been buried altogether by the change in strategy from product advocacy to change process advocacy. A distribution system for other than conventional commercial products is also lacking. The manner in which the emerging dissemination network may become (or become linked to) a distribution system is still unclear.

5. The Future

At the present point in time, the linkage functions of marketing/distribution/dissemination/diffusion, must be assessed as underdeveloped and weak in their impact on the user system. If they are to be strengthened, collaborative federal/state/local and private/public initiatives will be needed, designed specifically to take into account the essential requirements of the dissemination/linkage functions and the current state of development of these functions in the field of education. As a basis for suggesting key needs, we will review our understandings of its assessment basis and current status. In our discussion here, we will focus on dissemination.

Assessment Basis

The function of dissemination is critical to the entire R/D&I system. It is, in essence, a linkage process which "connects" knowledge producers with knowledge users. Thus, as we have been implying, the R/D&I dissemination system must provide for mechanisms which: can determine what is available; can sort out the "good" from the "bad"; will allow users to identify and obtain the particular products which are relevant to their needs; as needed, can "tailor" products to fit user needs; can motivate users to "try" a product; insures effective user implementation and utilization.

Assessment, then, must be made in terms of capacity to achieve and success in each of the above requirements. Overall we would wish to know this with respect to:

1. Extent and quality of "reach" into user systems (e.g.: number being reached, the extent of repeat utilization of dissemination services, and user satisfaction with such service).

2. Levels of user awareness and trial of R&D products (existence, character, and evaluative).

3. Contribution to implementation and utilization of R&D products. Since this depends on such other factors as number and quality of products available, user skills and receptivity, etc., the dissemination function can only be assessed as a contributor to the process. This must of necessity be a qualitative evaluation.

4. The existence of a well developed and cooperative network of dissemination mechanisms giving coverage across the nation and to the variety of users to be found.

Current Status

In education, we find a number of problems and barriers to dissemina-

ERIC

tion. There are an enormous number of users (some 17,000 school districts - - plus teachers, etc.), among whom there is wide diversity and variety as to philosophy, interests, perceived needs, etc. Innovations make demands on the time of school personnel (a very practical matter) and generally require "people change" - - factors which can lead to resistance to innovation. Additionally, at least two major factors have tended to create a very poor climate for dissemination in education: (1) a lack of implementation/utilization support to the user; and (2) the perception that the outputs of the (for the most part) newly created R&D system have generally been inferior to existing user-developed products.

In education, there has been a considerable amount of activity that has been called dissemination, and a large number and variety of organizations are involved in some kind of dissemination - - but much of this has been fragmented and scattered (e.g.: "add-ons" to development projects; successful but separate and discrete dissemination systems for specific categorical programs). As yet, however, there is relatively little coordination of federal, state and local resources nationwide, and no systematic way of tapping into the whole nationwide resource base. Further, there is not yet a well developed personnel base of trained dissemination specialists. Several federally funded programs have been developed in recent years for training dissemination and utilization specialists, but dissemination mechanisms are expanding far more rapidly and creating a far greater demand for trained personnel than these programs could even hope to keep up with.

Key Needs

From an overview perspective, then, the need is for:

1. orchestration of educational R/D&I dissemination from a total system perspective;

2. in the short term, facilitating the work of existing dissemination mechanisms and "filling" critical "gaps";

3. in the long term, providing for overall system building (this calls for policies and strategies which are proactive, not passive or reactive, and which are based on a knowledge of what does and does not in fact exist); and

4. balancing short and long term needs.

More specifically, policies and strategies federal funding agencies will need to be developed in collaboration with the states to focus upon:

1. quality control;

2. mechanisms that can optimize product/dissemination/user "fits";

3. providing users with alternative channels of access to the available resource base (a "mixed strategy" approach).

Keeping in mind the limited level and rate at which users can absorb new input once a dissemination system is established (a factor which is of critical importance), dissemination policy will need either to expand the dissemination technical assistance capability or slow the rate of dissemination system expansion. To achieve a balanced and appropriate growth rate, ongoing monitoring of the dissemination function will be essential.

XV. ACQUISITION

The weakness of the dissemination/linkage functions and their minimal impact on the user system become particularly evident from examination of the acquisition process in the user system, and the problems faced by user personnel in learning about and acquiring externally developed R&D outputs.

1. A Virtually Non-Existent Function

The acquisition function is virtually non-existent in education as an institutionalized activity. The purchasing specialty that one sees in industry is either totally lacking in education or (where it does exist) tends to be highly restricted in scope to little more than handling the paper work of purchase orders and invoices. Search, product evaluation and assessment of bids are confined to purchases of conventional supplies and equipment - - e.g.: paper, crayons, and chalk rather than textbooks, new curricula, or instructional systems.

2. Causes and Effects of Acquisition Weaknesses

The weaknesses of acquisition processes in education are a consequence of two conditions:

1. The marketing/distribution/dissemination/diffusion systems in education have been so inadequately developed, so diffuse in structure and so uncoordinated in channels that the educational marketplace is chaotic in nature.

2. There is a general absence of specialized resources allocated to the acquisition function.

A. Difficulties Facing User System Personnel

Thus, user system personnel face great difficulty in learning about or evaluating the alternative programs or products on the market to meet a given need. There is no systematic mechanism to link potential users to available suppliers, or even to inform the potential user about who these suppliers are or what programs or products they have to offer.

Individual development organizations provide catalogues of their own output but there are few comprehensive guides. Even those few which were intended to provide comprehensive coverage of the outputs of a given set of institutions [30] or the outputs produced under funding from specific agencies [84] or outputs oriented toward specific areas of practioners' needs [41] tend to provide less than complete coverage, or information in a form less useful than needed.

B. Absence of Evaluative Information

Perhaps most critical of all, there are few gatekeeping quality control mechanisms to screen out weak innovations and there is little evaluative information about available products and practices. There have been some recent initiatives to provide validity/quality control mechanisms on the federal and state levels (e.g.: the federal Joint Dissemination Review Panel established to validate selected educational R/D&I outputs, and state programs set up to validate "exemplary practices"). However, these have been too limited to have significant impact. In the absence of well established widely used bases for rational decision making about whether or not to replace existing practices or materials with new products or R&D outputs, faddism has been characteristic of school system adoption of educational innovation. Even where evaluative information about a product is made available to potential users, validated products of this kind are competing with a large volume of nonvalidated products and practices. [74] Thus, it is still difficult for the potential user to make a rational choice among alternatives.

3. An NIE Response

NIE has recently begun funding programs designed to provide uniform, comparative evaluative information across the whole range of products and practices available to meet a given need (e.g.: the 1976 Catalogue of NIE Education Products; the product information packages accessed in ERIC; and NIE's Consumer Information Program). It will take some time before we will be in a position to assess whether this new strategy has been effective in providing some order to the educational marketplace and needed supports for the acquisition function.

If this strategy is to have as much impact as possible, the target of the strategy within the user system will need to be narrowed. At present, the acquisition entry points are scattered throughout the system. The awareness, interest, information search, etc. that bring a new product or innovation into the acquisition decision process may begin with teachers, principals, curriculum specialists, the Superintendent or members of his staff, or even parents or community residents -- virtually anyone in the system or its environment. This can be a source of strength for the acquisition function. At present, however, it is relatively rare to find anyone responsible for initiating and carrying out acquisition activities as a major part of his job. Therefore the process remains episodic, haphazard, and random -- not well integrated into system functioning and long range planning.

There is suggestive evidence that the most innovative school districts may be those that are best linked to the external resource system -- either because of the professionalism of the teaching staff; or the leadership orientations and style of the principals or Superintendent; or the presence of external change agents; or especially the existence of curriculum specialists or coordinators on the staff who devote time and attention to determining what materials and products are available for acquisition.[4, 9, 73] Therefore, initiatives to improve the efficiency and effectiveness of the acquisition function by providing more and better linkages to the external resource system would appear to be a potentially potent strategy. These linkages could be developed either by providing more specialized personnel responsible within the system for stimulating and coordinating acquisition activities; or by providing materials or technical assistance personnel to provide this stimulation and coordination from outside the system.

The latter strategy is at the core of NIE's new Consumer Information and R&D Utilization programs. Together, they propose to: (1) provide targetted materials designed to inform practitioners about what existing theory and empirical research suggest about specific problem areas; how this relates to existing and exemplary practices; and what R&D products and programs are available to meet given needs; and (2) provide technical assistance personnel to help schools select, adapt, install, and utilize available products and practices to meet their needs.(83, 89, 91) If these programs are effective and widespread in impact, the acquisition function will be strengthened and significant gains will have been made toward achieving the R/D&I system goal of improving educational practice. At present, however, the acquisition function remains random and episodic, and its impact on school system functioning is limited at best.

XVI. IMPLEMENTATION AND UTILIZATION

1. A Neglected Function

Implementation/utilization has been one of the least understood and most neglected of the R/D&I functional specialties in education -- diffusion research generally ended at the point adoption decisions were made by school officials, thereby ignoring the implementation/utilization stages of innovation.

The study of implementation/utilization was spurred by the contradiction between research results that showed high levels of innovation as measured by adoption decisions but low levels of innovation when classroom practices were observed. As researchers began to examine what happened to innovations after the adoption stage, they discovered that innovations were in fact not implemented at all; or were transformed during implementation into "more of the same old thing"; or were terminated as ineffective within only a few years. The failure of innovations to survive the installation and trial periods was traced to two rather different kinds of problems:

1. on the one hand, resistance to the innovations by operating personnel because of attitudes, norms, and user system constraints;

2. on the other hand, technical complexities and difficulties requiring capabilities beyond those of operating personnel (in the absence of implementation supports that were rarely provided).[57, 119]

2. The Knowledge Base

There is an extensive knowledge base about user system norms, values, and various kinds of constraints that make teachers, principals, and other operating personnel resist certain kinds of innovations.[26, 27, 114, 119, 125] Far less is known about the technical problems and the kinds of implementation supports needed to overcome these problems -- or how to identify potential technical problems; assess user personnel capabilities in relation to these technical problems; and design training programs, technical assistance roles, and other required implementation supports. However, there is suggestive evidence that the technical problems may be of far greater significance for determining the fate of an innovation than attitudinal problems. More practice-based research and systematic evaluation of implementation support strategies will be needed to develop an adequate knowledge base to permit efficient and effective attack on the technical problems of innovation implementation in education.

3. Emergence of Linkage Organizations

A number of types of linkage organizations supporting the implementation process have been emerging in the education sector in recent years. We would include here: external groups such as training organizations, technical assistance groups and various types of educational consulting firms; internal organizational units where they exist (e.g.: a school district's teacher trainers, OD and renewal teams, etc.); and especially the state and interstate networks of school service organizations that have been promoted by recent state and federal initiatives.[91]

The implementation support strategies used by these organizations appear to lean more heavily toward a clinical change model of working with clients to adapt innovations to local circumstances -- as contrasted with the R&D delivery model of assisting school districts in acquiring standardized products developed by R&D organizations. However, beyond this general orientation suggested by the literature, we know very little about the nature or scope of this institutional base; how many organizations there are, and of what various types; how they are distributed geographically and by services provided; how many school districts they serve; what strategies they use and with what degrees of effectiveness; what personnel bases and other resources they draw on; the nature of their linkages with KP as well as KU, or with other linkage organizations; etc.

4. NIE

The state and interstate networks have been given increased visibility and some increased support from NIE's sponsorship of its R&D Utilization program. State networks of regional intermediate service agencies have been developed in approximately 25 states, and some other states have developed implementation support programs using other organizational arrangements. Interstate networks of various kinds have also been organized to link schools and districts dealing with similar problems or using similar innovative approaches (e.g.: ES '70 Schools; the Network of Innovative Schools; and the RBS network of schools using Individually Prescribed Instruction). The NIE R&D Utilization program described in a recent NIE RFP will fund selected proejcts organized into four configurations of implementation support agencies:

1. state organized systems of intermediate service agencies;

2. state systems not using intermediate service agencies;

3. interstate consortia of schools organized as groups of users;

4. interstate consortia of agencies primarily devoted to producing R&D outcomes and/or delivering technical assistance.(91)

By specifying the type of organization that will be supported, this project is likely to stimulate the development of this kind of networking as well as provide support for already functioning networks. The data assembled from this program and NIE's KPU monitoring program are likely to increase our understanding of the institutional bases that exist for conduct of the implementation/utilization support function; what proportion of the approximately 17,000 school districts in this country are served by these organizations; the activities that define this function in the education sector; and perhaps also the relative effectiveness of different implementation support strategies. At present, there is little in the literature to provide a clear picture of the nature and extent of the implementation/utilization support function as it exists today in the education sector.

XVII. SUPPORT SERVICES

1. Changes in Support System Patterns

As educational research and R&D activities have expanded in scale, the traditional research pattern of the individual scholar working relatively alone in his study or his laboratory has been replaced by team research under complex organizational and inter-organizational arrangements, supported by a complex subordinate system of mostly sector-spanning private corporations providing services and supplying and maintaining equipment.

Included in this support system are the traditional research support services -- e.g.: research libraries and suppliers and maintainers of the equipment used in the laboratories. Also included, however, are suppliers and maintainers of the kinds of equipment and services that distinguish the newer, larger-scale research and R&D from the older, smaller-scale research and R&D pattern -- e.g.: computer centers, data processing service bureaus, and computer maintenance services; the suppliers and maintainers of calculators, photocopiers, typewriters and other office equipment and of the various kinds of audiovisual hardware that are becoming so prominent in instructional system development; the film laboratories, videotape editing facilities, cassette reproduction laboratories, and printing and publishing facilities that play such important support roles in the production of materials and complex multi-media instructional systems; survey research service organizations that play a dual role both as R/D&I performers on projects of their own and as suppliers of support services for other R/D&I organizations; and the various mechanisms and arrangements that exist to protect proprietary rights for R&D outputs that are not clearly in the public domain. Included too, especially for the larger and more complex projects, are secretarial and clerical services, generally but not always provided internally.

2. An Inadequate Knowledge Base for the Support Service Function

There is relatively little in the published literature about the subordinate system of support services for educational R/D&I. We assume that there is a great deal of information in the files of federal agencies and R/D&I organizations that would be useful for assessing the scale, distribution, organizational capabilities, and client service patterns of the various support systems; the relative cost-effectiveness of the in-house vs. external strategies for supplying different support services (e.g.; data processing or survey research units) for different purposes, in different types of organizational settings; and the strengths and weaknesses of various kinds of procurement arrangements that are used. Transfer of support system management strategies from other sectors might be accomplished with relative ease once the configuration, dimensions, and service patterns of the support system for educational R/D&I are clarified, and related to those contextual conditions that function as constraints on the procurement and provision of support services for the educational R/D&I system. However, without such basic information, we are not in a position to attempt to transfer successful strategies from other sectors to the education sector.

XVIII. EVALUATION RESEARCH

1. Historical Context

Of all the R/D&I functions in the education sector, evaluation research has experienced the most rapid and extensive development in the last ten to twelve years.

Prior to the mid-'60s, evaluation of educational programs (when it was done at all), was carried out by educational practitioners and by some researchers -- but rarely by people who identified themselves as evaluation research specialists. The approaches tended to be normative, but rarely systematic or rigorous. The predominant strategy was casual observation and analysis. Conclusions tended to be based on expert opinion, intuition, and impression rather than systematically gathered and rigorously analyzed empirical data.

This pattern changed significantly in the '60s as large-scale federally funded social programs proliferated, and the legislation that created them tended to require the systematic gathering, analysis, and reporting of empirical data on program effectiveness. Thus, the evaluation research function expanded rapidly as a new specialty, even as a new industry: in less than a decade DHEW and Department of Labor evaluation contracts expanded from a $5 million to a nearly $50 million industry.(43) 1971 data for DHEW evaluation contracts indicate that 74% of these funds went to non-profit and for-profit research corporations, and only 21% to universities or university-affiliated organizations.(1) Many of the research corporations are sector-spanning institutions, bidding on evaluation contracts in education, health, personnel base development, social welfare, and (in the case of some of the more diversified research organizations and management consulting firms) industry, defense, and aerospace as well.

The expansion and maturation of the evaluation research function in education must be viewed as part of this broader development of the field of social program evaluation -- showing the same large increases in numbers of evaluators and amounts of evaluation activity; the same growing influence of research corporations competing with universities for evaluation contracts; and the same kinds of attention to methodological, organizational, and political issues inherent in the evaluation role.

2. Methodological Issues

During the '60s and early '70s, there were many heated debates among evaluation and research theorists about appropriate methodologies for the evaluation research function. One group argued that experimental (or quasi-experimental) designs were more powerful than any other research approaches for assessing the effectiveness of programs, products, or strategies -- and that it was therefore essential to use these approaches to test R&D outputs and to reform programs of all kinds.[10] A second group argued that experimental approaches imposed unrealistic constraints on field settings -- and that at any rate it could never be possible to meet adequately the statistical, design, and treatment assumptions on which experimental approaches are premised.[53, 135]

Other methodological debates revolved around the need for evaluation approaches to provide feedback throughout the program development process -- not simply telling the developer at the end of the development process that his program did not work, but working with him throughout the process to make it better.[121] Existing pre-post evaluation designs made it difficult for program evaluators to provide this kind of feedback, or to understand how to evaluate a program stimulus that kept changing.

Some of these disagreements have been eased by recognition among evaluation researchers that there are a number of different kinds of evaluation services, each requiring somewhat different approaches and techniques. The distinction between formative and summative evaluations represents one such difference. Initially, the same researchers conducted both formative and summative evaluations, but over time there appears to have been some specialization of personnel and organizational units here.

Currently, the formative evaluations that are undertaken as part of the R&D program/product development process are generally carried out by evaluators who work with developers as part of the development team and provide ongoing feedback designed to improve the product or program being developed. They use both quantitative data-based and qualitative judgmental approaches. Their style of functioning emphasizes flexibility -- changing their research questions, variables, instruments, and approaches as the emerging program takes shape and perhaps goes through a number of transformations.

The debate over experimental vs. other kinds of research designs is now centered on summative evaluations -- the evaluations undertaken to test the effectiveness of a given program or product after it has been fully developed. Summative evaluations are usually done by an evaluation agency or organizational unit independent of the program's developers. Summative evaluations include several types of evaluations differing somewhat in emphases because of the different information needs of the decision makers to whom they are addressed:

1. final operational field tests of an R&D output to help the R/D&I manager determine whether or not it is ready for dissemination;

2. evaluations of the effectiveness of a given program or product in a given school or district in meeting locally defined objectives;

3. evaluations of national program initiatives, sampling program components nationwide to inform federal policymakers about the effectiveness of a given strategy (or the relative effectiveness of alternative strategies) in meeting federally defined policy goals.

There is still some disagreement about how appropriate experimental designs may be for product tests and for individual school or school district program evaluations; and many other kinds of research designs have been proposed for these types of evaluations. Nonetheless, a federal program evaluation policy (to whatever extent such a policy exists) appears to be moving toward experimental approaches -- increasing numbers of national program evaluations are being conducted using experimental designs, control groups, and some randomization of treatments.(43) However, the difference between experimental setting in the laboratory and the field is gaining recognition. Federal evaluators are increasingly acknowledging the need to supplement impact data with process data demonstrating that a given "treatment" was in fact implemented as specified in the program design, and that the impact evaluation is a valid test of the program and not simply a "non-event." (13) Otherwise, questions can readily be raised as to whether a program evaluated as a failure was in fact a failure -- ~~or~~ whether instead it was never even tried (and thus what was evaluated and judged a "failure" did not in reality even resemble the specified program "treatment").

3. Organizational and Political Dilemmas

A. The Evaluator's Role

The evaluator's role has come to be understood primarily as one of meeting the information needs of decision makers.(134, 135) However, there are a number of issues and problems involved in this assumption. For example:

Which decision makers are we talking about: implementation personnel? program managers at specific sites? program managers at the local, state and/or federal level? policy makers (and at what level)?

How does the evaluator deal with the difficulty decision makers have in defining their information needs; in agreeing on what information is relevant or in agreeing on what measurement procedures and instruments are valid?

How much input can an evaluator have in defining what he investigates? Must he accept the client's definition of the program's objectives and simply assess the effectiveness of the program in meeting these objectives? Or can he include in his evaluation consideration of the appropriateness of these objectives (or the program's rationale or strategy) for meeting the ultimate goal of the program's developers?

B. The Political Dilemma

Evaluations are often described as management tools designed to provide a "rational basis for decision making" -- but decision makers in the public sector function in a largely political sphere. This fact raises important issues for the evaluator on both theoretical and practical levels.

On the theoretical level, we must ask if political considerations are "irrational," or if they are based on "a different model of rationality" from the one generally used by social scientists.(146)

On the practical level, consideration must be given to the politics of decision making. Generally speaking, programs are created by political coalitions of diverse interests -- interests which support programs for diverse reasons. These coalitions tend to view negative evaluation research findings unfavorably -- and generally have enough influence to modify or bury negative findings and keep their programs going regardless of what evaluators report. Conversely (yet similarly), programs may be opposed by other political interest groups -- interest groups who will use findings of evaluation research to achieve their ends. Thus, evaluation research findings may be used, misused, modified, reinterpreted, buried, etc.(21, 145, 146) -- in other words, used as a "political football". Given the political context and the methodological issues we have noted above, it is not surprising that controversy over negative evaluation research findings are so often phrased in terms of methodological issues rather than evaluation findings per se.

C. The "Value" Dilemma

The educational context is value-laden, and value choices enter virtually every one of the key decisions made by the evaluator. The outcome of evaluation research may be predetermined by the choice of research questions and objectives, the criteria used in judging effectiveness, or the measurement instruments administered. From the human perspective, the question must be asked: Is the evaluator value-free when doing evaluation research? From the organizational/political context perspective, the question must be asked: To what extent is/should these key value decision choices of the evaluator be influenced by the organizational information needs of the decision maker on the one hand, and the political context/dynamics on the other hand?

D. Current Trends

Evaluators are developing an increasing sensitivity to the politics of decision making. The evaluation research literature has shown the progress made by the field over time in coping with this situation -- from an early literature that simply bemoaned this situation, to more recent writings that accept it as a given and build consideration of the politics of decision making into the planning and implementation of evaluations to make them more "strategically useful". (75, 146)

The evaluation research function is in a much stronger organizational and political position now than it was a decade ago. Instead of being located in marginal units that could be easily ignored, planning and evaluation units and their administrators are now included in the top management decision structures of federal agencies.[43] The evaluation research function is taking on increasing prominence in the General Accounting Office's auditing activities.[131] On the state level, legislative oversight committees with strong evaluation research staffs of their own have given significant visibility to evaluation research activities and findings.[80]

4. The Impact of Evaluation Research in the Education Sector

There is still substantial disagreement over just how much impact the evaluation research function has had (or can have) -- but clearly, there is relatively little evidence of extensive use of evaluation research findings as the basis of policy decisions. Equally clearly, relatively few high quality evaluations have been produced and even the better evaluations have suffered from serious methodological flaws. The field of evaluation research lacks an adequate theoretical base, and is even more lacking in adequate instrumentation. There is no clear federal evaluation research policy, and federal agencies have not even issued guidelines as to what constitutes an adequate or appropriate evaluation. (OE, though, has been moving in this direction and beyond for the evaluation of ESEA Title I programs).[64, 104, 106, 136] It would seem, then, that the evaluation research function in the federally funded social program field remains weak in comparison to the evaluation research function in mature R/D&I systems.

XIX. RESEARCH ON R/D&I

1. Availability of Analysis and Empirical Research

Given the relatively brief history of educational R/D&I, there is an astonishingly large accumulation of analyses and empirical research on the functioning of the system. This is attributable in part to the negative political climate in which the system functions -- the lack of confidence in Congress and various federal agencies in the educational R/D&I enterprise. As noted earlier, there has been a tendency to pull the system out by its roots every couple of years to see how well it is growing and to determine how its effectiveness might be improved. A large number of these analyses were conducted by or for federal agencies or Congressional committees.[36, 105, 107, 117, 130]

A second factor of some importance in accounting for the large number of analyses was the increasing self-consciousness of the social sciences in the late '60s as to their proper role in relation to governmental agencies and the utilization of social science knowledge. Some of the relevant literature was provided by study committees of the National Academy of Sciences - National Research Council; the National Science Board; the National Academy of Education; and the President's Science Advisory Committee.[8, 34, 81, 82]

Some of the relevant literature is traceable to an international stimulus -- a request from the Organization for Economic Cooperation and Development (OECD) for OE to participate in a cross-national review of educational R&D and an analysis of how R&D might be strengthened to increase its potential for improving educational practice.[73, 109]

Some of the more recent literature is the result of the emergence of knowledge production/utilization as a new research area in the educational research community.(123)

But probably the most important impetus of all in recent years has come from the sponsors of educational R/D&I (not only OE and NIE but also private foundations such as Russell Sage) -- e.g.: their increasing interest in evaluation research as a basis for policy formation;(11, 45) their initiatives to support the design, development, and utilization of routinely collected data bases for monitoring the progress of the educational KPU system, detecting problems, and determining the impact of policy initiatives.(37, 71, 92, 95, 122)

2. Types of Studies in the Literature

The literature can be categorized into five types of studies:

1. distillations of expert analysis and opinion;

2. systematic empirical evaluations of particular components or outputs of the educational R/D&I system;

3. syntheses of the relevant literature;

4. case studies of exemplary educational R/D&I projects; and

5. descriptions of the KPU data base and monitoring system that is being developed under NIE auspices.

Most of the relevant literature (and virtually all of it that was produced during the first five or six years of the federally funded system's history) falls into the "distillation of expert analysis and opinion" category. These analyses were generally based on interviews; site visits; examination of materials in agency files; perusal of system outputs; or the insight of scholars working together to form judgments and make recommendations.(2, 3, 14, 15, 16)

Systematic empirical investigations make up the second largest category -- e.g.: evaluations of personnel training programs;[124] or ERIC information products;[46, 143] or pilot state dissemination projects;[67, 127, 129, 141] or AERA meetings and journal publications as critical elements in the KP information flow system in education;[99, 101] etc.

We include here especially several studies of the evaluation research function -- how it is organized; who does what kinds of evaluations with what degree of effectiveness; how evaluation findings are used; etc.[1, 6, 45] The "research-on-research" character of these studies of the evaluation research function suggests a particularly high level of self-awareness within this function.

There are relatively few documents in the other three categories. The literature that is available clearly reflects the institutionalization of "research-on-research" in educational R/D&I -- efforts to synthesize the existing literature;[93, 103, 115] efforts to map the domain of educational R/D&I;[18, 35, 115] and descriptions of NIE's KPU monitoring project designed to: develop a data base on educational KPU functioning; use the data base to build models of the dynamics of KPU functioning in education; and monitor KPU functioning to identify problems requiring new policy initiatives or to assess the effects of existing policies and policy changes.[92, 95]

At present, the research literature on educational R/D&I functioning touches on only limited areas of system functioning; provides relatively little empirical data; is atheoretical; and appears to be only minimally utilized by either sponsors or performers of R/D&I activity. However, all of this may change if the NIE monitoring project is effective in institutionalizing research on the educational R/D&I system and providing the kind of data base and policy analyses suggested in current project descriptions.

XX. CONCLUSION

We have throughout this report noted weaknesses in the educational R/D&I system. It is important now to re-emphasize that we have also noted that what we have found would be generally what one would expect to have found within a relatively young R/D&I system. There has been progress, and there are signs of the beginnings of a transition from the introductory stages of system development.

Thus, as we noted at the outset, the current state of the educational R/D&I system must be assessed in terms of where it has been and where it now has the potential to go - - not in terms of unrealistic expectations about "progress and output to date".

With this perspective in mind, we can see the last two decades as a period of some important achievements in the creating and building of the educational R/D&I system in the United States. As compared to twenty years ago:

1. There are today some 1500-3000 organizations (academic, private, and public) which have R/D&I capacity - - most of this capacity being relatively new and being largely the result of federal funding.

2. The personnel base has doubled (perhaps tripled) - - from around 4000 in 1969 to 8-12,000 in 1974. Most of this work force is represented by research and development personnel.

3. The educational R/D&I system has produced a substantial number of outputs. Some of these have been outstanding quality and of a widely reported excellence - - products from R&D organizations and exemplary products which have been identified, generalized and widely disseminated.

4. Some linkages have been developed between some of the strong development organizations and the school systems who have been using their products.

5. Since some degree of maturity of a knowledge/technology base is necessary to allow its codification into handbooks and other syntheses, we may infer some beginnings of educational R/D&I system maturity from the increasing level of availability of such handbooks/syntheses.

As the R/D&I system has matured, inevitably some of the functions have developed and/or been supported more than others. It will be important to maintain a "balance" between these various functions of the educational R/D&I system. This balance must take into account for each function:

1. the time period needed to produce significant outputs;

2. the impact each function has on the other functions;

3. the level of funding needed both to maintain a balance and to maintain the basic integrity of the personnel and institutional base within each function.

4. what currently does/does not exist within each function (in terms of outputs and of the institutional personnel, knowledge and technology bases).

In summary, the period of the last two decades has been an important era of initial system building for the educational R/D&I system. There remain problems, weaknesses, critical gaps to be filled, balances to be achieved -- as one would expect to find in a relatively young R/D&I system. These identified needs become the focus for system building and rebuilding for the next transitional phase for the next five to ten years. In this period, it will be vital to provide continuity, stability and security in order that the educational R/D&I system can take root, grow and develop maturity. Only in these ways can we hope to develop a maturing educational R/D&I system which can have significant impact on the educational system in the United States.

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CHAPTER FOUR

THE R/D&I CONTEXT IN THE CIVILIAN AVIATION SECTOR

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THE R/D&I CONTEXT IN THE CIVILIAN AVIATION SECTOR

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Figure 6 -- Partial Model of Main Institutions in the Aviation R/D&I System

CHAPTER FOUR

THE R/D&I CONTEXT IN THE CIVILIAN AVIATION SECTOR

Since 1959 the term "aerospace industry" has been used to denote the industrial sector serving both space and aircraft development and production. Space work has been almost entirely devoted to serving the federal civilian and military exploration programs, while aircraft manufacturing serves both military and commercial users. For our purposes, discussion of the space and military aircraft cases would involve issues of lesser interest (given the specific nature and requirements of the users) than the case of the civilian aircraft industry, although, as will be seen, it is not possible to completely separate these subsectors. Therefore, the primary focus of our contextual analysis will be set within the civilian aviation industry.

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I. ENVIRONMENTS OF THE R/D&I SYSTEM

1. Political Conditions

A. Federal Funding

Federal funds going into industrial R&D in the aerospace industry have tended to exceed company funds in the ratio of about 5 to 1 (DOT [13]). As we noted above, each of the significant stages of development in aircraft technology between 1926 to 1971 were preceded by periods of government funded R&D. On top of this, it is federal money that supports the work of NASA, the source of most of the basic research in the field. Not surprisingly therefore it has been in the Congress and in the Executive branch (including at NASA itself) that much of the decision making on the rate and direction of equipment R&D has been made. Additionally the roles of FAA and DOT have been significant in the determination of airline policies and procedures, and in turn, on policies and procedures of the manufacturers of airline system products. Whether we are referring to prices, schedules, safety, flight patterns, maintenance requirements etc., it must be remembered that the airlines industry is highly regulated.

B. International Relations

Another important political aspect is the role that aviation plays in international relations. Having a major airline has long been a matter of national prestige. Even small countries that can ill afford the investment support their own flag carriers (even at substantial loss in revenue) for reasons of prestige or for security (as might be claimed, for example, by Israel*).

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Equally (or more) important has been the fact that most of the free world flies in American made equipment, this time with economic as well as political implications. The Anglo-French Concorde project is at least as much a political as an economic venture. In fact it is probable that flights of these planes will need to be (and will be) highly subsidized by their respective governments to help establish them in the marketplace. The present political battle over landing rights for the Concorde has been said to have major implications for U.S. relations with Britain and France. Also, considerable concern exists over the possibilities of the U.S.S.R. becoming a source of aviation equipment.

2. Social Conditions

This has all been taking place during a period in which social acceptance of airline travel has become established. During a period of approximately 25 years revenue passenger miles has increased an average rate of about 13% per annum, rising to 20% or more in some years(11). Over the period of the last twenty years both total world and U.S. airlines have experienced an approximately twentyfold growth, and estimates for the 1976-85 period are for 50 billion dollars (worldwide) of commercial aircraft deliveries (at constant 1974 dollars), almost as much as in the previous 25 years(13).

The enormous and growing demand for the service and the product (coupled with the tremendous rate of change of the technology) indicated a user population that was "pulling" new R/D&I outputs in a most intensive manner -- although Schiffel (29) believes that traffic growth acts as a "permissive" factor rather than as a cause of aircraft technological innovation and acquisition by airlines. The fact is that the use of the airplane as a means of passenger and cargo transportation is established; and there is a pattern of expectations for continual improvement in service (allowing for the effects of fuel crises, etc.), even though demand may now have stabilized.

*Although El Al does not in fact represent such a drain on that economy.

3. Economic Factors

A. Federal Expenditures

Changing patterns of federal expenditures on space and defense have had enormous impact on the aerospace industry. The industry has a reputation of feast and famine conditions, with major layoffs and rehiring of even the most qualified personnel being common. The federal bail-out of the Lockheed Corporation is a well known event.

As we stated above, federal funding for aeronautics R&D has been substantial. During the nine years of 1967-75, approximately seventeen billion dollars was spent by the federal government, with nearly two billion of this in NASA. Further, the trend has been up -- approximately 50% over the overall period, and almost tripled at NASA (reflecting a shift back from space to aeronautics R&D). Such a level of support can hardly be ignored.

B. The Technological - Economic Interaction

It is also a fact that it is difficult to understand the technological and R/D&I system issues in the aviation industry without an appreciation of the effect which economic forces and structures have on the producers of aircraft and their airline industry users. Let us examine this interplay of these techno-economic relationships.

1. Airlines

Airlines are oligopolies, highly regulated in the U.S. by the Civil Aeronautics Board (CAB). Fare competition is virtually non-existent both for major national airlines and in the international contest (under IATA control).

Two-thirds of the investment of airlines is devoted to purchase of aircraft.* Given industry-wide price controls, competition is transferred to service, image and operating cost differentials. To a considerable degree, as Schiffel (29) and Gellman (14) recognized, the acquisition of new aircraft by airlines becomes a competitive device -- and as we would note, a defensive strategy (you can't afford to be using obsolete equipment at the same ticket price for less service). This strategy has been made possible by the continuing pattern of increasing demand (traffic), at least up to recent times.

2. Aircraft Producers

Aircraft producers (essentially the airframe manufacturers) are, by now, also members of a highly concentrated oligopoly, with only three major manufacturers (Boeing, McDonnell Douglas and Lockheed) left in the U.S. industry (which in practice represents most of the non-communist world's civilian aircraft capacity). Other firms such as Convair and Martin have been forced out of the competition, with ever-growing tooling costs demanding long production runs and hence concentration permitting economies of scale.

Demand for new aircraft, while growing at a substantial rate, is not easily or quickly expanded beyond this pattern. The limited number of major airlines seek to minimize the variety of aircraft they use for a specific application (e.g.: long vs. short haul) in order to keep down operating and maintenance costs. Aircraft have relatively short first-line life cycles# because of rapid rates of change in technological opportunity (frequently deriving from technology transfer from the military sphere).

* Recent trends towards leasing aircraft from equipment trust funds may be helping airlines to alleviate this major financing problem.

Although equipment may be kept on for less competitive applications for 15-25 years, and even longer in the aftermarket.

The previously mentioned shift to service differentials (as opposed to price) as the arena for airline competition creates an enormous incentive for producers to be on the market with new products first -- or not far behind. Because diffusion rates for adoption across the airline industry is rapid, airlines must commit themselves early to a new range of equipment -- and the latecoming producer is squeezed out. The consequence has been fierce technological competition between manufacturers. Further, unlike certain other fields, it is virtually impossible to play the role of a technological follower who substitutes marketing "clout" for technological innovation. The performance characteristics (speed, range, capacity, noise, operating cost per mile, etc.) are too clear and quantifiable across most criteria to permit manipulation of a sophisticated customer, the airlines.

3. Other Economic Factors

Recent public concerns with environmental effects (noise pollution, etc.) may act to herald in a new wave product innovation that the airlines will not be able to resist, despite the negative economic implications that this would have on them.

The changing economics of fuel may force the introduction of more economical equipment. Thus, for example, the airlines and airframe manufacturers have in the past shown little interest in the NASA super-critical wing technology that could promise a few percentage points of improvement in flight performance (and hence reduce fuel utilization). The arena for cost reduction as the airlines saw it lay in the total cost of operations more than in flight costs. While this still may be true, the sharp jump in aviation fuel prices has led to an upsurge of interest in this new technology.

Another important consideration has been the substantial role of aviation exports (civilian and military) as a factor in the U.S. balance of payments, and the increasing threat of foreign competition. In 1971 aerospace exports surpassed 4 billion dollars. Brizendine (8) estimated that 93% by value of the free world's civil transport came from the U.S. The ten year forecast for the total market is over 50 billion dollars.* In such an environment R&D must and does receive a high priority.

4. Scientific and Technological Conditions

A. A Well Developed Scientific and Technological Field

While the history that we have presented spans only seventy years, the scientific roots of some of the central disciplines can be traced back to the contributions of Leonardo da Vinci, Gallileo, and Newton, with later work by Leonhard Euler and Daniel Bernoulli in aerodynamics.

Modern aerodynamics dates from the turn of the last century with the work of Lanchester in England; Kutta, Von Karman and Prandtl in Germany; and Zhukovski in Russia. In the years since, the field, with its associated fields of structures and materials, has become a highly developed, scientific and engineering based specialty, with substantial experimental facilities such as wind tunnels being constructed. Aero engines date from 1851 (by the Frenchman Giffard, applied to airships) and from the work of the Wrights and Manly in 1903, with continued and accelerating developments through the second world war. The work of Whittle and others starting in 1939 in England and Germany ushered in the jet age in the mid-1949's.

In the internal combustion and jet engine technologies, we are by now dealing with a very well understood and documented field, amenable to classical processes of scientific and engineering

*It is to be noted, however, that return on sales in the aerospace industry has tended to be around 2.5 to 3.0% compared with about 4.5-5.5% for all manufacturing firms, although return on stockholders equity is about the same (DOT, (13) p. 68).

improvement. The advances in aeronautical electronics are more recent but fall into the same pattern, with especially rapid advances in recent years with the progress of the field at large. All together the subfields can generally be seen as highly specialized, scientifically and engineering based, and highly codified. Standards are a way of life for every detail and feature.

An exception to the above pattern is the more recent concern with human factors and use characteristics. In these areas (e.g.: as these might relate to cockpit and controls designs to provide high effectiveness, low fatigue, etc.) and in the areas of passenger facilities designs, etc., less developed areas of knowledge are being used. Similar problems arise in considerations of the man-machine system aspects of flight, command and control, safety, etc.

B. Innovations: Abrupt or Cumulative?

We would be remiss in our discussion if we lead the reader to conclude that there is a continuing flow of radical and large scale innovations stemming from fundamental (i.e.: "breakthrough") changes in the state of the art leading rather abruptly and automatically into major new applications. There have been (and continue to be) considerable and continual ~~advances in components and materials,~~ some traceable to fundamental advances; and these surface, from time to time, in new aircraft configurations and models having radically upgraded characteristics. But it could also be claimed that there have been no really radical innovations in aircraft from the time of the first jet planes up to the recent NASA developed super-critical wing technology. It can be claimed that what we have seen has been a series of cumulative (though very significant) improvements. This is a perspective that is open to much debate, but it is congruent with the view expressed by Abernathy and Wayne[1] in their discussion of the "learning curve." Regardless of which viewpoint is "correct", we should note that the <u>net result</u> of innovative activity in DOD, NASA and industry has been a very significant trend of performance improvement over the last few decades.

C. The Technological Imperative vs. User Needs

The importance of technology transfer from military to civilian aviation has already been noted. Such effects can be seen along the whole history of civilian aviation, through the various wars, into the jet age and even recently with the wide body jets such as the Boeing 747 (coming from the Air Force C5A built by Lockheed). The developments generated in this way have tended to push technology in the directions of greater speed, range and capacity. Thus, over the last forty years civilian aircraft have increased their cruise speed by a factor of three; their range by a factor of ten; and their capacities (pay load) by factors of twenty to forty. In general, though not always, there have also been comparable improvements in economy; and measured on a cost per seat mile, there has been a one-third reduction over the same period.

However, as we pointed out and as we will demonstrate later, the objectives of R/D&I programs in the military and civilian spheres are not alike, given the varying patterns of needs. With much of the new aviation technology having flowed from the military, it was only to be expected that rate and direction of such innovation did not necessarily match the changing pattern of needs of the airlines or the ultimate consumers (passengers and shippers of freight). As a consequence, new technological opportunities were being opened up in ways and at a rate that were not necessarily to the advantage of the airlines to implement and exploit, but which they found themselves being forced to adopt because of the defensive non-price competition we noted earlier. These conditions lead us to look to the producer as the source and stimulator of the technological innovation process vis a vis the airline users.

There are, however, other causes that point in the same direction and which might be expected to continue even in the absence of the external military source of technology. An airplane is a highly complex multi-component system, with many of these components operating close to their technological limits and using state of the art knowledge. As advances emerge in materials, structures, configurations, electronics, and engine design, new technical possibilities appear. These developments may have derived from many sources, inside and outside of the aerospace R/D&I systems. The research and design fields are so specialized that one time we may see advances in fuselage design; at another in flaps or wings; at another in controls and so on. A new aircraft system may, as we noted, emerge through an accumulation of many improvements in many components -- sometimes adding up to a substantial upgrading in performance. Again, such improvements may or may not coincide with user demands -- but the technological imperative and stringency of the technological demands nonetheless require aircraft and component manufacturers to be pursuing ever-continuous programs of research and development.

D. Signs of Increasing Civilian Aviation Autonomy

The drive of externally (military) fueled innovation may have culminated in the 1970 SST program. We will discuss the goals of aviation R/D&I programs later, but for now we may recognize that an SST meets virtually none of the objectives that seem to reflect the needs of airlines for new generations of equipment. It represents only an improvement in speed (made possible by the generations of supersonic military aircraft now in service). It is retrogressive on capacity, fuel consumption, range, cost of operation and environmental aspects. This does not imply that SSTs will not find a place in the market. Rather, the debate may indicate a maturation watershed for the industry. We earlier indicated 1970 as the achievement of full maturity. It may be that it marks the point at which the civilian aviation industry began to pull away from the military source of technological innovation -- perhaps even leading to a more complete separation of the military and civilian sectors. The implications could be to make the patterns of innovation so well discussed by Schiffel (29) less relevant for the future trends.

Related technological developments may be going on in the less glamorous areas of aviation innovation. In response to the growing potentials in developing countries (in the freight business, etc.), there is a growing interest in supplying low cost, short take-off and landing equipment. A combination of closer fitting of products to user needs, a substantial after-market (used planes), a growing concern by airlines in influencing the emergent features of the equipment they purchase, and the previously mentioned increasingly close coupling of NASA aircraft research with the civilian aviation industry, may all be signs of the growing autonomy of the civilian aircraft industry.

E. Summary

The nature of the aviation industry makes it vital that we recognize the extent to which the industry lives on its technological innovation base and the degree to which its policies and strategies are technologically determined.

II. HISTORICAL DEVELOPMENT

1. Development of the Sector and the R/D&I System: Institutionalization

The R/D&I process in civilian aviation could be described as highly institutionalized. More than seventy years have gone by since the first successful flight in 1903. Since then a highly developed and specialized industrial sector has grown up with a well defined division of activities both as to research and development and production roles. Substantial and specialized companies (e.g.: Boeing, McDonnell Douglas) are to be found in the areas of airframe (aircraft) manufacturing as well as in engines (e.g.: General Electric) and in other equipment (including segments of the electronics industry). In addition, the National Aeronautics and Space Administration (NASA) -- which was established in 1958 to replace the National Advisory Committee for Aeronautics (NACA), founded in 1915 -- has well defined responsibilities in the more basic R&D areas. The Department of Transportation (DOT) and the Federal Aviation Agency (FAA) have clearly deliniated roles in the implementation evaluation and control of aviation systems.

A. The History of Industrial Development

In a history of the U.S. Aircraft Industry, Simonson [31] described the period of 1903 - 1930 as that of the early industrial development. Stekler [33] described the 1903 to 1914 period as being that of initial development. Up through the end of 1913 only about 100 airplanes had been built. Stekler refers to 1914 to 1939 as the World War I and interwar period. During this period production rose to a rate of 14,000 planes per year in 1918;

Several sources were especially helpful in supplementing the experience of the authors with this sector. They are: AIAA,[4] CAB,[11] DOT,[13] Schiffel,[29] Simonson [31] and Stekler.[33] The comments of Drs. Alden S. Bean of NSF and Frank A. Spencer of Northwestern University who reviewed this section were extremely helpful.

dropping off after the war and in the depression era; and then growing steadily until 1939, during which year not quite 6,000 planes were built -- almost 4,000 of which were for civilian use.[2] World War II saw production rise to close to 100,000 per year, then settling down to around 10,000 per year (including the Korean War period).

The first specialized air transport manufacturing began in 1926 with the Ford Tri-motor[13] and by the mid 1950's the airline industry as the major civilian customer was well established. Since then until today, the industry can be viewed as having achieved the status of a mature sector with a steady pattern of growth and development. The superimposed cycles of (military) activity and the growth and partial decline of the NASA space program since the late 1950's have tended to produce something of a more volatile characteristic than for other mature industrial sectors.

We might characterize the period up through 1913 as the pre-birth phase; 1914-1939 as the introductory phase; 1940 through the early 1950's as the transition phase and the late 1950's up through 1970* as the climb to maturity; with the last few years as the beginning of the matured phase of the industry, using the Rubenstein, Radnor, Baker and McColly schema.[28]

B. Development of the Aeronautics R/D&I System

Paralleling this development of the industry has been that of the aeronautics R/D&I system. The lag in establishing an R&D base for

*The date of the rejection in Congress of the SST program and the beginning of growing airline concern with costs and idle capacity.

the aeronautics sector was relatively short - as can be seen by the early establishment of the NACA (1915), the forerunner of the present day NASA organization.*

Throughout its relatively short history the technologies of airframe design and materials, engine design, and materials and electronics have been subject to very great rates of change. These were described in a recent workshop on the Role of Technology in Commercial Aircraft Policy Formation (4) as a "very perishable property", with even relatively advanced models of aircraft being phased out in seven or eight years (p. 30). A Department of Transportation report (13) (p.8) described nine stages of aircraft development from 1926 (with the Ford Tri-Motor) through 1971 (with the DC-10/L-1011), with each being predeced by a period of R&D (largely funded by the U.S. government). Stekler (33) (p.96) took note of the increasing role of R&D as compared to production as the industry developed. This degree of dependence on R&D and the close coupling with the maturation of the industry permits us to recognize that the R/D&I system has come through the same stages of development as the secotr, with little lag even at the start, and reaching a point in our time when it could be viewed as totally established in the industry.

C. Changes in Experimental and Test Facility Requirements

An additional factor leading to the degree of institutionalization of the aviation R/D&I system has come from the changing character of the experimental and test facilities required. In our era, such work can only go on when there is access to very large scale facilities (wind tunnels, flight test facilities, large computers, etc.) The consequence has been to centralize such work in NASA, the Department of Defense (DOD) and the large aeronautics firms - essentially

*The British had set up a similar effort six years earlier (1901) at the National Physical Laboratory. The Germans pursued such research at this time at Göttingen and the Russians at Koutchino.

eliminating much of the diffused university based efforts in anything but the most fundamental areas (mathematical, materials and physics). This mirrors the similar institutionalizing effects on High Energy Physics due to the need for larger experimental facilities (accelerators) as found by Radnor, Zaltman et al. [27]

2. Critical Events

A. Creation of Federal Agencies

The creation of NACA in 1915 was a landmark in the development of the U.S. aeronautics R/D&I system. A great deal of the central R&D can be traced back to work at the Langley, Lewis and other research centers that were created by NACA and which became the sources or seed beds upon which the later NASA was to be built. Federal support for aeronautics (including civilian) has always been a major factor; and by the 1958 National Aeronautics and Space Act and the Federal Aviation Act (FAA)* of the same year, "Congress made provision for nonmilitary aeronautical activities,"[13] thereby supplementing the DOD aeronautics efforts in the military sphere. The National Aeronautics and Space Council was set up to coordinate related aeronautical activities.

B. Key Historical Events

Without question the onset of World Wars I and II (and to a lesser degree the Korean War) generated major impetuses in the development of aeronautics technology, R/D&I systems and the industry at large. Significant technical developments were pushed to accelerated fruition, notably, in electronics, radar, and jet propulsion in the World War II case. The cold war acted to continue the pace of technological development in the military sphere. While there are important

*Incorporated in the Department of Transportation Act of 1966.

differences in the needs of military versus civilian aircraft requirements (to be discussed later), there has at all times bended to be a significant degree of technology transfer. Another important influence derives from the consequences of the accelerated space program of the 1960's (the Apollo-man on the moon program in particular; but not exclusively). A 1970 event of some significance was the Congressional decision not to support the development of Supersonic Transport (SST) in competition with the Anglo-French Concorde and Russian Tupolev 144 SST. The recent concerns with the energy shortage, cost, and the environment (air pollution and especially for noise) -- coming on the heels of the phasedown of the enormous space effort -- have lead to something of a revival of civilian-focused aeronautics R&D as a major priority for NASA programs.

C. Current Developments in the State of the Art

Besides the SST efforts*, some of the current developments in the state of the arts concern the design of more economical and better performing aircraft (using NASA-developed super critical wing and area rule-based configuration technologies); the design of overall systems of improved cost and safety features; and short and vertical take-off and landing aircraft. Particularly important has been the role of the airlines, with their own substantial R&D capabilities in the total design and implementation of systems into which the aircraft fit as one component (although to date, the airlines lack similar R&D capabilities in the equipment design sphere).

*Basic research is continuing at NASA.

D. Attitudes of the Public

An interesting comment on the general public's attitudes towards the products of the aeronautics R/D&I system and of the industry is the degree to which they are accepted with little or no question. New types of aircraft have been continually introduced into airline service with virtually immediate adoption by the ultimate users, indicating a faith in the quality of the R&D, testing and evaluation, and control processes.

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

1. The Structure of the Aviation R/D&I System

Very evident in the R/D&I system is the extensive specialization between institutions. Fundamental scientific research goes on in the universities to some degree and in NASA, which carries research toward the proof of concept stage. Equipment manufacturers carry the R/D&I process forward through equipment development, design, testing, and production stages. The airline users do no equipment R&D, restricting themselves to strictly defined implementation and utilization of equipment in the larger overall airline system. Even the equipment itself (the airplane) is specialized into major components -- airframe, engines, electronics (with even subdivisions within these systems) and many or most of these are subcontracted to producers who carry on their own R&D programs. The federal government supports the more basic research, private industry the applied work.*

*It is interesting to note that one of the arguments used in Congress to stop NASA's SST work was that in proposing to go on to a prototype stage they were encroaching on the private sector role.

Specialization goes even deeper, down to the scientists and engineers involved in the R&D process. For example, there are whole departments whose personnel may spend their lives on wing stress analysis.

Additional specialization is to be seen in the roles of FAA, DOT, and CAB, each responsible for researching and implementing specific phases of the overall air-transportation system. In turn, these governmental institutions have clearly defined control and regulation roles.

2. The Intra-System Structures

While the specialization is, as we noted, very great in the aviation R/D&I system, for the most part the work goes on in a very limited variety of institutional settings. Most of what goes on in the R/D&I system can be found at NASA (and DOD); at the airframe manufacturers and their associated (in parallel) subcontractors; and in the utilization R&D area with the airlines, with supplementary activity in DOT (FAA). Universities play a relatively minor role in the process. Figure 6 is a partial model representing these institutions and their relationships.

Thus there are three prime participants in the aviation R/D&I system: the basic technology sources (NASA and DOD in parallel), the equipment producers, and the users.* Each of these contribute specialized elements to the R/D&I process. Except for the indicated parallelism

*It should be noted that while there are other types of civilian users (e.g.: the private and corporate aircraft market) these tend not to be a major factor in the R/D&I system.

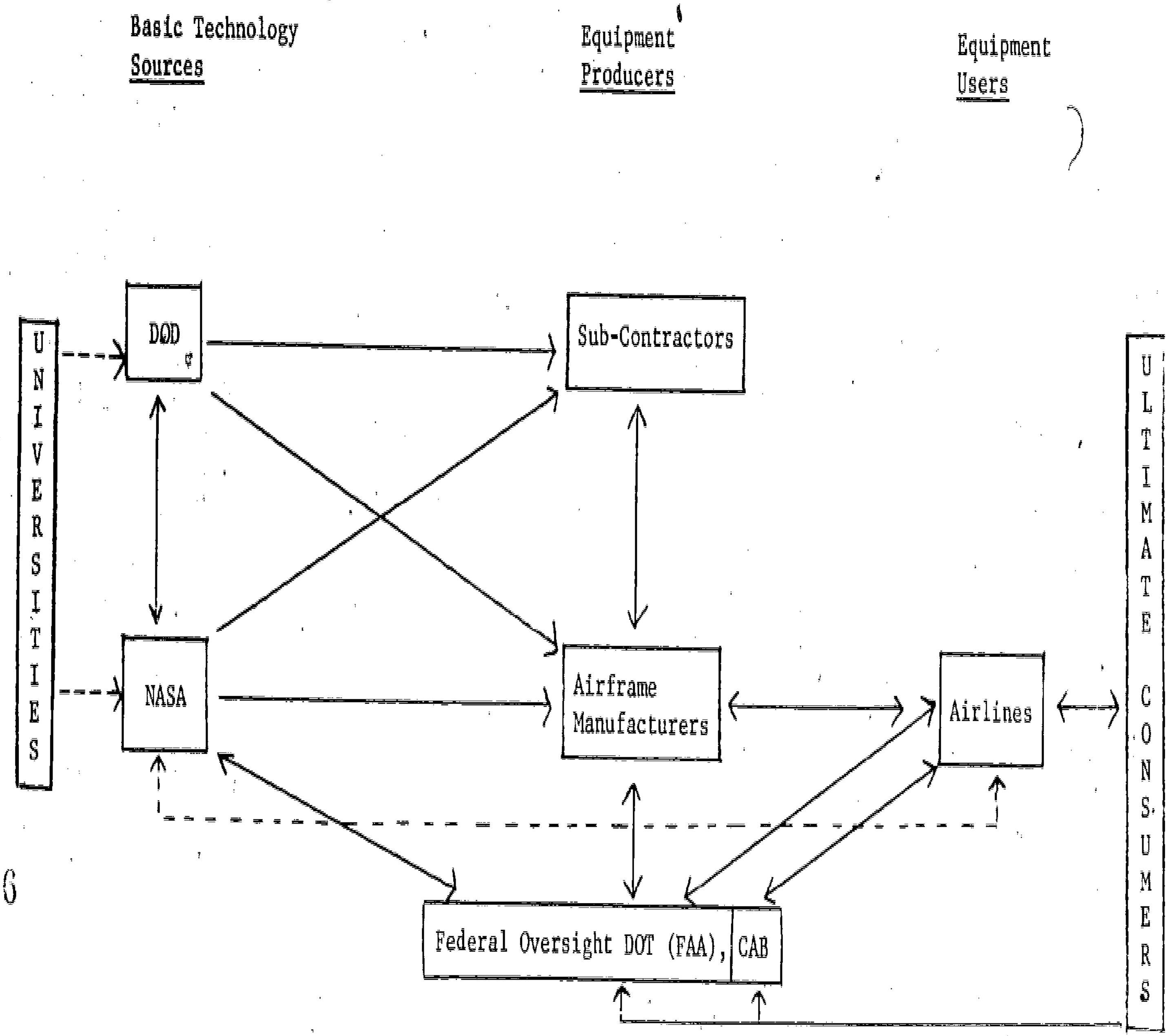

Figure 6

Partial Model of the Main Institutions in the Aviation R/D&I System (as between airframe manufacturers and subcontractors) the system is highly linear; there is a well established workflow; relationships tend to be most intensive between institutions with adjacent R/D&I functions; and so on. There are no obvious gaps between functions, although questions could be raised as to whether all of the most desirable linkages exist. For example, in some of our own research(6) we noted some potential shortcomings in the degree to which the airlines were connected into NASA's technological development in terms of their forward planning, and vice versa. The only areas of redundancy might be between some of the work going on in NASA/DOD and NSAS/DOT, and a federal committee was established to bring about necessary coordination.

3. R/D&I Institution Characteristics

The R/D&I system is dominated by very large institutions, whether we are referring to NASA, the major equipment manufacturers, or those airlines that play a meaningful role in the R/D&I process. While they are all highly formalized, their characteristics reflect their roles in the system.

NASA is made up of a series of research centers, each tending to specialize in some aspect of space and aviation technology. Aviation tends to represent only a smaller part of the overall NASA mission and is of concern to only a few of the centers. Some of these centers are involved in the more basic aspects of aeronautics or power plants, others in more applied flight systems programs. A center may have several thousand personnel, a large proportion of whom are scientists and engineers supported by technicians and other personnel. In their appearance and work styles these centers are university campus-like, but they are organized and managed in relatively formal ways. In the technical areas, personnel and departments are highly specialized.

Airframe manufacturers are structured like most high technology firms, but reflecting the special needs of aviation. Again there is very high specialization between departments which do R&D work, component design, systems designs, specifications, materials engineering, stress analysis, testing, etc. -- on through production, inspection, marketing, and so on. Airlines are structured around their roles of providing a service to the ultimate customers and are supported by numerous applied-research, analysis and system design groups. Manufacturers and airlines stay in close touch with each other at the commercial and technical levels. Airlines become involved in the usual market research and advertising functions to stay in touch with the users of their service -- hopefully identifying needs and demand.

Finally, we might note that cooperation, licensing, and even joint ventures are quite common. In addition to the already mentioned subcontracting that goes on between the airframe manufacturers and the producers of engines, electronics, etc., it is not uncommon to see several firms joining together to win a given government contract. The extensive specialization in the industry creates opportunities for manufacturers which can be realized through cooperation.

IV. GOALS, POLICIES, STRATEGIES

A vital initial parameter is the recognition of the size of the aeronautics R/D&I system. If we include federal funds, we are talking about an industry that spends something like six to seven billion dollars a year on combined space and aviation R&D (although only about 10% will be company funded). To this must be added the funds spent within NASA, DOD, etc., themselves. Even though the proportion of these vast amounts that are devoted to civilian aeronautics is the smaller part, it is still a very large amount, and it is embedded in and an integral part of the largest (by far) industrial R&D system.

1. Interaction Between Civilian and Military Aeronautics

As we noted, there has been a close historical interaction between military and civilian aeronautics. However, there are substantial differences in the goals of the R/D&I programs. In military R&D the programs are oriented towards the development of complete weapons systems emphasizing various aspects of performance (speed, maneuverability, hovering capabilities, as well as range and carrying load). For civilian applications (34) the objectives must be pointed towards improvements in economy (usually fuel consumption), maintenance costs (pay load), noise and polluction as well as faster cruise speed and greater range and capacity.* Nevertheless, there does tend to be a great deal of commonality in aeronautical requirements and technical disciplines(13) (p. 22). The tendency has been for the civilian sector to benefit thereby reducing the technical risk associated with the commercial application. In this sense, the military has been the field test proving ground for a great deal of advanced aeronautical technology going into civil aviation, although we have questioned this as a trend for the future.

2. Participants in the Civilian Aviation R/D&I System

Turning to the specific participants in the civilian aviation R/D&I system, the following can be observed (13) (p. 47):

> "NASA addresses the development of a research and technology program to support and enhance the various disciplines which encompass civil aeronautics. NASA also undertakes technology programs directed toward the solution of specific aircraft problem areas. Guidance is provided by the Federal Aviation Administration of the Department of Transportation (DOT/FAA) in terms of the perception of the need for technology application to both categories of interest. The government also derives assistance in developing guidance from joint government industry councils.
>
> DOT/FAA pursues airway and air traffic control technology, as well as airport and runway engineering and development, particularly as it applies to airport layout, traffic flow, vehicle movements and pavement design."

*The differences may be continuing to increase as military aircraft take on missile capabilities and characteristics.

In addition, we could add the role of the universities which serve as a source of fundamental knowledge to NASA and DOT and which also perform certain contracted research from these agencies. Then there are the industrial firms (airframe, engine and other component manufacturers) who do the applied development and engineering design work (airframe manufacturers do very little basic aeronautics research) through the prototype to production model stages. The objectives of these latter participants have already been stated in general technological and economics terms.

3. R&D Within Civilian Aviation

Airlines have done virtually no R&D on flight equipment. Their concerns have centered on the utilization of equipment as part of the total air transportation system. Thus, airline directed R/D&I has been focused[25] on aircraft maintenance, equipment scheduling, traffic flows, passenger handling, freight and baggage handling, ticket reservations, food and beverage service and in-flight passenger entertainment; i.e.: with implementation/utilization characteristics. Since the 1970's however, airlines have become increasingly concerned with aircraft and fuel costs, idle capacity, safety, environmental issues, etc. This concern has had the effect of increasing their perception of a role in the rate and direction of aircraft innovation (essentially along the lines of more planned, controlled and need oriented equipment programs). As a result, we have seen in the last few years something of a shift in R/D&I goals. As we noted, up through the early 1970's the emphasis was on the development of aircraft that could fly faster, higher and further, and with larger pay loads at comparable costs. It was these criteria that spawned the SST. Recent emphases have been towards economy (especially in fuel), utilization characteristics, environmental impact (with noise reduction being a major priority) and life cycle costs.

4. General

Looking across the spectrum of aviation R/D&I programs and objectives we can note that as we move from the universities through NASA to the producers and then users of aircraft, the time horizons tend to shorten, the objectives and applications become more specific. It is also important to have a sense of the balance between the research, development, design, prototype building, flight test, production designs and tooling stages. Expensive as the research may be at the NASA and even company levels it is small compared with the cost of the later development and engineering through tooling phases. The investments in these later stages can be enormous. Nevertheless, as Stekler[(33)] pointed out, the balance between R&D and production investments has been characterized by a continuous increase in role of R&D. Whether this has begun to plateau out remains to be seen.

V. ADMINISTRATIVE PROCESSES

While the aircraft industry is managed in a generally similar manner to most large scale industrial firms, there are a number of characteristics that are particular to this context. These characteristics relate to the need to manage a process that is so fundamentally R/D&I based; the structure of the industry (particularly the fact of the critical prime/subcontractor relationships); the enormous complexity of the equipment systems; the highly codified and specified information and data base; the extent of external regulation and control; and the previously discussed economic and financial structure of the industry.

These conditions have given rise to a large number of management methods that have come to be known as aerospace management methods. These have to do with the management and control of large scale R&D projects, systems engineering and management, simulation techniques, forecasting methods, cost/benefit studies, reliability studies, contracting techniques, logistics methods, etc. The success of these methods in their application to this industry has lead some to suggest that they might be more widely disseminated, without always recognizing that their applicability may be limited by the specialized context of their source.

To attempt a complete review of the aerospace administrative process function would require an analysis far too extensive for this illustrative analysis. Instead, we will simply list here 25 specific techniques and concepts derived from the aerospace industry as discussed by Milliken and Morrison.[21] It is to be borne in mind that their paper was written for the general business community (in the Harvard Business Review) with a view to promoting the possible diffusion of these techniques and concepts.

1. Systems Analysis
2. Cost/Effectiveness
3. Decision Analysis
4. Heuristics
5. Simulation Modeling
6. Forecasting
7. Delphi
8. Systems Engineering
9. Reliability Analysis
10. Maintainability Analysis
11. Value Engineering
12. Project Management
13. Matrix Structure
14. Government/Private Corporations
15. Procurement Systems
16. SEB Process
17. Incentive Contracting
18. Contractor Performance Evaluation
19. Management Information Systems
20. Reporting Display Systems
21. Scheduling/Status Recording
22. PERT/CPM
23. Configuration Management
24. Logistics Management
25. Quality Assurance

VI. PERSONNEL BASE

The aircraft industry uses very large numbers of scientists and engineers as well as other highly skilled management and control personnel. In 1971 out of a total employment of over one million, 175,000 were scientists and engineers (it had been 56,000 higher in 1967) and 58,000 technicians.[13] These tend to be highly specialized personnel, and having the proper mix and quantity of personnel in specific areas is critical. Use of skills inventories is one method of keeping on top of this issue.

The industry is notorious for its ups and downs (mostly reflecting the shifts in military and space programs) resulting in massive hirings and layoffs of highly skilled personnel. This can be misleading to the outside observer. Thus a great deal of skilled technical work in developing an aircraft consists of highly programmed detailing (e.g., stress analysis). In many ways this is R&D production work. When large numbers of engineers are laid off the brunt of the cutting is in these direct R&D production areas. Protected are the core R/D&I personnel without whom it would be impossible to develop future programs. Even for the core group there must be turnover. The high rate of obsolescence of skills demands a continual infusion of new blood.

Salary levels tend to be high and there appears to be some status associated with working in the industry. Naturally there is great mobility within the industry, as various firms wax and wane with the success of their programs.

VII. FUNDING

The importance of U.S. government funding has already been mentioned (the government was largely responsible for supporting the R&D that preceded most of the major technological advances). Over the ten year period of 1958-68, the federal government spent about $5 billion per year on industrial R&D in aerospace, while companies were spending between $1/2 to $1 billion per year of their own funds. Fitzsimmons of McDonnel Douglas[4] estimated that in 1974 total U.S. aeronautics R&D was "down to a total of something like 10 percent of civil sales." This would generate something like $6 to $8 billion in civil aeronautics R&D by 1985. Together this represents an enormous R&D base (even though most of the direct expenses may have been non-civilian oriented.)

Funds from the U.S. government that can benefit civilian applications are those going to NASA for specific research programs, and the independent R&D allowed on defense contracts. Company funds must be generated by sales.* This has tended to produce instability for firms.

The life cycle of a development program through production up to first sales can be very long. Firms must risk very large investments in R&D, tooling and first production before much revenue comes in to repay the investment. The elapsed time could easily exceed ten years.

Average rates of return tend to be somewhat below the rest of industry. Combined with the high risks, the sector has not proved attractive enough to keep all the firms in or attract new entries, resulting in the oligopoly situation to be found today. Without governmental support of one sort or another, the predominant role of U.S. manufacturers and the flow of innovation would not have been possible.

VIII. INFORMATION FLOW

At the basic research level (but excluding work from the military sphere) the flow of information within the industry and between industry and government tends to be relatively free. There is wide exchange of ideas, even on an international level, with publication, laboratory visits, etc., being common and hence essentially uncontrollable. In the more applied development and design phases, in the application to production, companies attempt to control information flow and to maintain secrecy.

IX. INNOVATIONS

The innovations in the aviation sector have very large-scale requirements.

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*Direct to airlines or to institutions who then lease to airlines.

Costs are enormous, especially for development, but there is a large amount of federal funding of basic and applied research, and (through DOD contracts) of development. As the innovations themselves are very close to the state of the art, there is a high level of complexity and sophistication of technologies involved. Many highly skilled, specialized personnel are required. Long time spans are involved. Thus, very complex R/D&I systems are required. We find coordination and orchestration of the system being done by NASA at the research stage and by airframe manufacturers at the development through implementation stages - - and cooperative relations throughout the innovation process with support service organizations.

From the user side of the R/D&I process, the innovation requirements involve performance/cost improvements and the need for the innovations to "fit" into the user's operating system and capabilities.

Additional requirements exist in terms of the multitude of governmental regulatory and control activities in relation to performance, safety, etc.

The real life cycle of civilian aviation innovations is quite long - - indeed the older propeller planes have had very long real life cycles. Safety and air worthiness are the basic criteria for the limits of real life, requiring a continual process of maintenance and updating of equipment. While the real life is long, the competitive life in the initial, primary market is much shorter - - with aircraft being sold to an "after market" (small airlines; cargo) before the real life cycle is completed.

The quality of the innovation is a critical element of the R/D&I process - - both in terms of the objectives of cost/performance improvements and in terms of safety and reliability factors (as already noted). Thus, the innovations must be (and actually are) highly testable.

For the most part, the innovations are limited to aviation per se, but there is a fair degree of "spin off". Aircraft themselves can be adapted to a variety of applications (passenger/cargo; long or short haul; military/commercial).

From the perspective of transportation objectives, innovations in the civilian aviation sector have been of great benefit to society. However, we have already noted that many people are beginning to question the larger costs of noise and environmental pollution; and that innovations have at times been "forced" onto the airline companies.

X. NEED IDENTIFICATION

The degree to which airline needs for flight equipment are determined by a complex interaction of competitive and technological forces has already been discussed. From this we saw that it is difficult to separate airframe manufacturer responsiveness to airline needs from their behavior in generating these needs. Thus the locus of need identification can be visualized as the intersection of ultimate consumer demand as transmitted through airline planning and the output of the aircraft production R/D&I system.

Airlines depend on market research, demand analysis and sophisticated planning functions to identify and translate ultimate consumer demand into equipment requirements, in the light of techno/economic/political conditions. These are converted into equipment operating, economic and environmental requirements. Equipment producers stay in close touch with the airlines own need identification efforts but attempt to achieve a leadership position by translating technological opportunity into features that meet current, potential or stimulatable user needs. Since producers must ultimately compete for the airline equipment business (despite the oligopoly structure of the industry), something of a balance between the airlines and the equipment producers is achieved. That this balance is not always totally achieved is demonstrated by the recent airline experience in over-acquisition of wide body (jumbo) jets, which generated considerable over and idle capacity; and by some of the apparently less than ethical tactics of manufacturers in their marketing efforts, which have been coming to light in recent days. In general, however, the process that can be observed over many years has been one of relatively smooth integration of emerging technology into new equipment that meets the changing patterns of consumer demand.

XI. GENERATION/RESEARCH

We can usefully introduce this section by quoting directly from the American Institute of Aeronautics and Astronautics [(4)] statement on the Design of Aircraft (p. 30):

> "Design technology, as it relates to the field of commercial aircraft, is largely conceptual in nature. It constitutes the basis for the selection of not only the final product itself, but also the individual components or supporting elements of that product. In another sense, it includes the methodology used in realizing the basic design concept, as well as the logical integration of the many individual elements -- components, subsystems, and procedures -- into the complete, functional aircraft system.
>
> It is possible, of course, to identify and to discuss the specific technological elements of the design process; e.g., computer-aided structural, aeroelastic, and aerodynamic design methods, supercritical aerodynamics, "winglet" vortex dissipators, graphite-epoxy composite structural elements, numerically-controlled manufacturing processes, etc.."

The above statement well illustrates the extent to which the development and design phases of the R/D&I process depend on detailed and scientifically based bodies of fundamental knowledge in physics, fluid dynamics, structures, materials, etc., as well as in combustion, heat transfer, electronics, and so on, for the non-airframe components.

This knowledge comes from basic research going on at the universities, but more substantially at NASA and DOD and to some degree in industry, with this last sector taking on the major applied research role. Both laboratory and field research are involved. materials testing laboratories, enormous wind tunnels, simulators and large scale computers combine with extensive flight testing of new concepts to provide the experimental base for the aeronautics parts of the field, with similar situations existing for the R&D on engines and electronics, etc.. This phase of research generally stops short of prototype development.

The nature of the R&D is such that it is often carried out by teams rather than individual researchers, with many project teams reaching very large size. While creativity is important (as always), progress more typically occurs through the accumulation of a myriad of detail advances in the state of the art. Really revolutionary new concepts have been relatively few. In the civilian sphere (as opposed to the military) publication of results at the basic research level is fast and open. Interstage technology transfer is achieved rapidly and efficiently. Even though, as we noted, much of the research goes on in large mission oriented institutions (NASA, DOD, big companies), a very professional environment is maintained within well planned and controlled programs. NASA research centers, for example, provide research environments equal to or better than that at most universities.

R&D programs may be focused around specific applications (such as an SST or a vertical take off and landing [VTOL] aircraft, etc.), or around problem areas (materials, noise, energy, pollution, speed, etc.). In fact, something of a matrix exists between problem and product-directed programs, with a fair degree of interchangability. Thus, Congressional action could stop NASA's SST program but might still leave intact most of the applied research that was required for the SST objective. Thus it is possible today for NASA to be fairly advanced in SST research without having had such a program.*

*The maintenance of national technical readiness even without a hardware program is seen as one of NASA's missions.

XII. DEVELOPMENT

The really complex and high cost aspect of the R/D&I process is that which goes on within the industrial firms in the transition from prototype to production ready and tested designs. The design phase is critical for the success or failure of the firms in the industry. As we implied earlier and as Harlan(16) (p. 10) has noted, design is the arena of airframe manufacturer competition, leading potentially to major gains or losses of market share (i.e.: a much more sensitive situation than that which might be found, for example, even in the style conscious automobile industry).

Development of the prototype is a critical stage. Where this occurs is not always clear-cut. NASA typically modifies and experiments with aircraft as part of their research effort. At what point a new concept has emerged in prototype form is not always obvious, although formally the building of production prototypes is the role of the manufacturers -- and for specific models this is clear-cut.

Development through engineering and design processes is highly sophisticated and specialized. Numerous departments deal with component design, systems integration, performance analysis and testing, etc. The ultimate tests take place in flight testing.

Technology transfer is a critical element of the development function of the aviation R/D&I system. We have already mentioned the military-to-civilian aspect. For example, the development and purchase of a C5A transport by DOD from a given firm makes development of a civilian passenger aircraft of this same (wide body) type much more feasible.* Similarly, development of a new generation of equipment by one company will be quickly followed by its competitors. Far more difficult are attempts to transfer technology across national boundaries, as for example,

*Recent legislation forbidding prototype building on DOD contracts without a clear military mission may be limiting such inter-program technology transfer.

when companies in one country assemble aircraft (using some local components and materials) designed elsewhere (such as Fokker of Holland assembling Lockheed airplanes). Always difficult, this may be compounded by the very complexity of the aircraft system, with its highly critical interdependence of materials, design and function, and possibly reflecting cultural as well as economic and resource differences. Thus, for example, materials engineering became a major and near determining function in the effort of Israel Aircraft Industries to produce initially French-designed and then self-designed equipment.

XIII. PRODUCTION

1. A Custom Shop Process

The production process for aircraft is more reflective of a custom shop working on batch orders than that which laymen visualize as the typical high production industrial scene. While there are production shops that use presses, cutting and turning equipment, etc., to produce components, the main manufacturing areas are large hangar-like spaces in which a batch of aircraft are painstakingly built up, giving manufacturers a fair degree of flexibility in introducing new designs into the production process. The cost of tooling remains a major component of the total investment, since to an important degree each new aircraft system requires the design and fabrication of new manufacturing, assembly and test tooling -- much of it of a very costly nature. Nevertheless, as was noted by DOT[13] (p. 58) 75% of costs are in personnel (development as well as production) -- i.e.: it is a labor intensive industry.

2. Control Systems

The production control system is geared around the custom shop environment. Relatively little production is for stock, and most major airline customers require variations in features. Thus, production plans have to be geared to specific orders and customer determined delivery schedules. Since lead times for obtaining and manufacturing components and for the actual assembly are long, careful and detailed planning is required.

3. Structure of the Aircraft Manufacturing System

It is important to clarify the structure of the aircraft manufacturing system. As Harlan [16] noted, airframe manufacturers "do not manufacture, in the strict sense of the word, all the basic components of the planes they produce." Rather, the airframe manufacturers act as the "prime" producers of the equipment and they purchase engines, electronics, etc., from other industries who act as "subcontractors." Stekler [33] speaks of "prime contractors, associate prime contractors, subcontractors which manufacture systems, and subsystem manufacturers." In any case, the selection and control (cost, schedule and quality) of subcontractors becomes a major production issue for the prime airframe manufacturers[12,16].

4. Quality Control

Quality control and inspection (both in-process and final) are of central importance in the production process. Unlike most other products, aircraft manufacturers cannot afford to correct their mistakes in the field. Despite (or perhaps as indicated by) complaints to the contrary (compared to almost all other sectors), this industry can be seen as paying great attention to product quality and safety. Anything else would be disastrous in both social and economic terms. There is no place for seconds. This issue becomes compounded as a source of problems, given the great rate of obsolescence of aircraft and the consequent inability to upgrade quality and design over time as part of the usual learning curve. Another compounding problem is the degree to which materials and structures are extended to the feasible extremes of their capabilities in consort with the need to keep weight down to a minimum.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

This feature includes several aspects of the "bridging" function between knowledge producers and knowledge users. In the civilian aviation sector, the primary issue is marketing, and we will thus limit our discussion to marketing.

1. Market Growth

An important parameter for marketing is the fact that the airline market (as measured, for example, in revenue passenger miles) has had a substantial and steady growth. Some (e.g.: Steiner [32]) have projected that this will continue to grow at 6-8% per year over the next decade, so approaching 1,000 billion revenue passenger miles by 1985 (excluding the Communist world markets) -- which translates into a $60-80 billion aircraft sales market.

2. Individual Firms: Feast to Famine

While the gross volumes sound, and are, impressive, they must be evaluated in the light of their fluctuating character, particularly for any given firm. Given the changing character of equipment with the fact that demand may shift by substantial degrees following technological advances, firms may well swing from feast to famine. Actually, the military (rather than the civilian) markets have been the worst or most fickle customer as far as creating conditions of volume fluctuation for the manufacturers.

3. Product Positioning

The positioning of products as to capabilities, features and price is critical. Different aircraft can serve different markets more or less efficiently (or at all). Thus the type of equipment needed for trans-oceanic flight differs from those required for short haul internal travel. Also, [4] it has been stated that there is a growing need for thirty to fifty passenger aircraft designed for operation in short haul city center to city center markets (in response to a demand for such service in the U.S. and even more abroad), thus indicating a market segment that may be growing at a faster rate than others. New equipment must be designed to fit such changing market segmentation.

4. Predicting/Stimulating Future Demand

This indicates the importance of knowing and being able to predict and/or stimulate future equipment demands from airlines at home and abroad. It then becomes the task of top level sales personnel to obtain orders for sufficient volume to permit the manufacturers to make the necessary investments into tooling and manufacturing a new product, thereby establishing a market (usually with one or more major airlines) that others will follow. As noted above, Production, will, by and large, then be tied to the specific additional orders that can be generated. The previously discussed need for airlines to compete in non-price areas (through product and service differentiation), together with the matching of aircraft performance to service needs, becomes the focus of equipment sales efforts. Thus, close customer contact on a personal basis is obviously a requirement for successful sales efforts. The airlines attempt to capitalize on having innovations in equipment, usually by assigning them first to the most competitive routes (where possible) and by maximizing their publicity to promote their use of new equipment. (e.g.: as Pan American did with the Boeing 707's and 747's and American Airlines with the DC10's).

5. Obsolescent Equipment: The After-Market

It is of interest to consider what happens to the equipment that becomes obsolete in this process of rapid innovation and proactive marketing. There is a substantial after (used) market for aircraft in secondary airlines and cargo transportation. The ability of major airlines to sell obsolete equipment has helped them to finance the investment in new aircraft, thus helping fuel the innovation process. However, growing demands for such products may be offset by reductions in equipment life (of the big jets) and increased cost and complexity of maintenance. The future of the aircraft after-market and its impact on the R/D&I process has still to be determined.

6. Marketplace Characteristics

The economic and political characteristics of the marketplace are important. As noted, there are only a very few major airframe manufacturers. The number of airlines is greater, but in many of these cases (e.g.: for the national airlines of other countries), political and national economic considerations compete with airline economic factors in determining what is bought, when, and from whom. Additionally, an airplane must meet any local legal and regulatory requirements (e.g.: see the debate on permitting the Concorde landing rights in the U.S.) that may be slanted to serve national interests. Also, manufacturers may be supported to greater or lesser degrees by their governments for larger economic, security or prestige reasons (e.g.: Lockheed in the U.S. and Rolls Royce engines in the U.K., to name but two highly publicized examples.)

Finally, it is important to recognize that the major airlines (the smaller ones tend to follow their lead) are relatively sophisticated customers. They are well informed on the operating and technological characteristics of the products they buy, and highly skilled in their implementation and utiliaation. That is not to say that they do not make mistakes (as for example with the DC7's and Boeing 720's which turned out to be inferior to their predecessors, and the failure of the turbo-compound engines).

7. The Producer's Task

The producer's task is to create a set of conditions (technologically, competitively, price, delivery, and terms-wise) that make the purchase of his product the most rational decision for the airline to make [illegible] to the political, legal and economic considerations: e.g.: curr[illegible] availability, constraints that may be operating at the time).

XV. ACQUISITION

Airplanes are very expensive products, and, as we noted, represent the major part of an airline's investment. Airplanes are also a major determinant of their competitive capacity. That is to say, airlines cannot afford to fly inferior aircraft. Thus, deciding what to buy and when can be the most critical decision an airline can make. Airlines therefore make it their business to stay aware of new developments from their very earliest stages, even ordering before the first production airplane has been completed, in the hope of gaining a competitive position. They are equally prone to cancel orders if problems (performance, delivery, political or economic) appear -- creating a very unreliable market. A major continuing constraint is the ability to finance the rapid and expensive new product introductions that may make obsolete their present fleets.

Schiffel (29) lists the following factors which he says <u>should</u> be taken into account in making the acquisition decision:

1) Overall demand for air transportation and the demand in relevant specific markets;
2) Extent and character of price flexibility and competition;
3) Price (or rate or fare) level and structure;
4) Extent and character of non-price competition, including that embodied in flight equipment, enroute and ground services, etc.;
5) Extent and nature of market competition;
6) State of aviation technology;
7) Availability of investment capital;
8) Availability of "suitable" aircraft;
9) Capital cost of flight equipment;
10) Operating cost of flight equipment;
11) Exposure to risk; and,
12) Aircraft manufacturers' sales policies.

Equipment may be purchased because it is seen by an airline to have an optimal fit with its present route structure. However these structures can and do change and the impact on the "fit" may be hard to predict, sometimes leaving the airline with less that optimal aircraft for their routes.

Another important concept is that of the "launching purchaser", i.e., an airline that launches a new airplane by becoming its first acquirer and promoter (as did American Airlines with the DC 10 and Pan American with the Boeing 747). This gives the airline the initial competitive edge while absorbing the risk of introducing an innovation, and may lead to other airline adoptions, the objective of the manufacturer. Some foreign countries may give governmental support to their airlines to pursue such a policy (e.g.: in France).

Acquisition decisions are critical for the airlines. As we pointed out they are sophisticated buyers, even though mistakes have been made. With the ever-increasing cost for equipment and the growing financial constraints, the selection behavior has become even more analytical, displacing some of the "old boy" network considerations that may have tended to exist in the past. This need for careful analytical planning has become reinforced as airlines, particularly more recently, have come to recognize the system-wide implications of the aircraft acquisition decision.

XVI. IMPLEMENTATION AND UTILIZATION

1. Implementation

A. Close Producer/User Coordination

Implementation in the aviation industry often begins while the design is still on the drawing board. There is close coordination between producers and users to tailor the equipment to the needs

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of the airline. Even after the model is in general production, the specific order will be tailored to user desires. How the airline will use the aircraft and the criteria that will be used to evaluate performance are well defined in advance of implementation.

B. Implementation Requirements

The requirements to actually implement a new aircraft are many, With operating features such as speed, range and capacity likely to be changed by a new acquisition, revisions may be needed in operations, routes, schedules, etc. Maintenance requirements and facilities are likely to be different and will require preparation. This can be a costly and long process, demanding considerable pre-planning. Retraining requirements for crews and maintenance personnel can be very extensive. The general public may need to be prepared with major promotion programs. Trial runs will normally precede general introduction into scheduled flights. Thus, a decision to introduce new equipment usually implies a major change on a system wide basis. While the airlines are highly skilled in carrying out such changes, new acquisitions do generate major disruptions for airlines.

C. Software Aspects

So far our discussion has focused on the hardware aspects of the aircraft. At this point it is also important to note that there are software dimensions to the product that play a vital role in its implementation and utilization. The manuals, specifications books, parts lists, etc., that come with an airplane are unbelievably extensive. Complete specifications of operation, maintenance, parts, and so on are a vital component of an aircraft system. Without them, implementation would not be possible.

2. Utilization

A. System Impact

New equipment can be used to supplement existing aircraft in a growing market, or may be used to open up new routes where this is permitted and desirable. When it supplants existing aircraft, these may be moved to other routes or applications or sold in the after-market. When the change is a radical one (as was the first introduction of jets in the late 1950's) then a whole restructuring of the system is required to accomodate the new approach. Personnel and facilities need to be reoriented and changed.

B. Barriers

The incentives to innovate have already been discussed. The barriers are generally cost, customer acceptance and political, legal and regulatory constraints. There are also potential system level technological constraints and barriers. For example, not all airports had runways that were long or strong enough to take the first generations of jet transports. There may be similar deficiencies in air traffic control capabilities. Thus it is not enough to have a better airplane. The airplane must be capable of being congruent to the systems of which it becomes a part, or conditions must be extant that permit other system features to be upgraded (build better runways, etc.). Finally, we are today also recognizing the extent to which aircraft have an important impact on our environment and that this impact must be considered as a utilization criterion.

C. Servicing and Maintenance.

Once in service, aircraft must be serviced and maintained (including parts and components replacement) in a frequent, detailed and prescribed manner. Also, from time to time, changes will be incorporated requiring testing and approvals. Unlike most other equipment, aircraft have to be kept at a near-new condition at all times. Preventive maintenance and replacement is the norm. Failures of even minor components relating to the operation of the airplane can cause grounding. Costly spares have to be inventoried in various locations. This all adds up to a costly and critical aspect of equipment utilization.

XVII. SUPPORT SERVICES

Since the aircraft industry is in fact an amalgam of several industries (airframe, engines, aircraft electronics, etc.) it is not really feasible to discuss support systems as a separate feature. Many industries provide components to either the primes or subcontractors, and the cost of building an airplane would be prohibitive but for the existence of this structure of suppliers. Much the same could be said for the equipment (production and testing) suppliers, and for the many organizations providing services to airlines. Large airlines will have their own service functions in many areas. Small lines can contract these out. Various types of companies have emerged specializing in the provision of various kinds of services. Thus, Stekler (33) notes that there have even developed management companies providing systems management and coordination services (e.g.: TRW, Aerospace Corp.) to DOD and NASA.

XVIII. EVALUATION RESEARCH

As we noted, aircraft are subject to extensive component and system testing and evaluation through development and during and after production, with this meticulous process continuing into service (for equipment used to provide service to the public). No airplane can be introduced into commercial service which has not received FAA certification. Once in service detailed records have to be kept on flight history, maintenance records, changes, etc. Unusual experiences or crashes can lead to the grounding of all aircraft of a given type. When an anomaly or crash does occur, detailed investigations are made to identify the causes and to institute corrective actions as seen necessary. The airlines make their own cost, reliability and customer response evaluations of new equipment.

As we noted, the civilian area depended in the past on the military for considerable technology transfer which included reliability, safety and proof of concept data. The airlines would not generally buy an airplane that had not been flight tested by the military. With the divergence in needs and the changes in the law regarding DOD contracts, this may become far less feasible and hence represent a major added cost factor.

XIX. RESEARCH ON R/D&I

We are not aware of any previous attempt to analyze and describe the civilian aviation R/D&I system from a comprehensive contextual perspective. This is not to say that there has not been much research on various <u>aspects</u> of R/D&I in the civilian aviation sector. Obviously, much has been done, as the list of references at the end of this chapter will indicate. Thus, we find many studies on such aspects of civilian aviation R/D&I as the economics of the aircraft and airlines industries[10, 24, 29, 32, 33, 34]; the nature of the industry[2, 7, 11, 13, 15, 20, 30, 31]; the effects of technology on economy[23, 25, 26] and on the industry[4]; on the technology per se[3, 5, 8, 17, 19, 22]; on planning and operations[6, 12, 16, 18, 21]; etc.

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See also references in the Milliken and Morrison (1973) paper included as part of this discussion.

CHAPTER FIVE

AN ILLUSTRATIVE CROSS-SECTIONAL COMPARATIVE CONTEXTUAL ANALYSIS

AN ILLUSTRATIVE CROSS-SECTIONAL COMPARATIVE CONTEXTUAL ANALYSIS

1. ENVIRONMENTS OF THE R/D&I SYSTEM
2. HISTORICAL DEVELOPMENT
3. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)
4. GOALS, POLICIES, STRATEGIES
5. ADMINISTRATIVE PROCESSES
6. PERSONNEL BASE
7. FUNDING
8. INFORMATION FLOW
9. INNOVATIONS
10. NEED IDENTIFICATION
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12. DEVELOPMENT
13. PRODUCTION
14. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION
15. ACQUISITION
16. IMPLEMENTATION AND UTILIZATION
17. SUPPORT SERVICES
18. EVALUATION RESEARCH
19. RESEARCH ON R/D&I

CHAPTER FIVE

AN ILLUSTRATIVE CROSS-SECTORAL COMPARATIVE CONTEXTUAL ANALYSIS

In the previous two chapters, we have illustrated how the CISST contextual analytical framework may be used to describe the overall context for R/D&I in two sectors: education and civilian aviation. In a later volume, we will provide similar illustrative contextual analyses of the health, the law enforcement equipment and the civilian industry sectors.*

This later volume will also include a cross-sectoral comparative analysis of R/D&I. While a full cross-sectoral comparison would be beyond the intended scope of this report, there is merit in providing here some insight into the process and utility of cross-sectoral comparative analysis beyond that which the reader could glean from a reading of Chapters Three and Four (the education and civilian aviation sectors).

To provide such an insight, we have chosen to present a summary of the five contextual analyses to be included in the later volume (health, law enforcement, civilian aviation, education and industry). This summary is presented in a table format on the following pages. The more detailed discussions of the education and civilian aviation sectors in Chapters Three and Four should facilitate understanding of the brief summary context descriptions provided in this chapter.

This chapter, then, should provide some insight into the similarities and differences between sectors -- and by so doing, provide some insight into the process and utility of comparative contextual analysis of R/D&I.

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*Further, another later volume will (as already noted) be devoted to a much more detailed contextual analysis of the education sector than the illustrative analysis in Chapter Three.

1. Environments of the R/D&I System

	Health	Law Enforcement	Civilian Aviation	Education	Industry
Political	Federal primary funding source AMA lobby AHA lobby High level of support Strict FDA regulation	Sensitive to environment Responds to political environment	Heavy federal support Congress and Executive decision making on R&D FAA and DOT roles Regulated industry International prestige Recent Congressional suspicion of industry	Vulnerability, open to pressure Education operating system paid for with public funds under local, lay control; therefore, local influence on acquisition/utilization Subject to scrutiny and debate Decentralization (in US) Lack of congressional confidence in R&D	Strong industry/government interaction in space, defense, and recently energy, but most industry subsectors are left to own initiatives in R&D. Increasing trend toward regulatory controls impacting on R&D - EPA OSHA, FDA, FCC.
Level of Support	Very high	Medium high	High	Weak	Varied. High in space and defense-areas of national interest. Otherwise low.
Level of Demands	Heavy	High	Medium	Needs high; demand for products or materials high, but not necessarily high for external R/D&I	High - especially on consumer products.
Credibility/ Status	High	Low	High	Low	High
Social	Ready consumer market Malpractice suits Concern for ethics Better informed patients (Health is value laden)	Sensitive to environment--responds (rather than anticipates) (L. E. is value laden)	Growing demand - may be flattening Environmental and safety concerns	Vulnerable, open to pressure Low legitimacy of professional expertise (Education is value laden)	Mixed. Encourages entrepreneurs, gives high status to scientists and engineers, but lack of awareness of need to develop industrial R&D.

1. Environments of the R/D&I System (Continued)

	Health	Law Enforcement	Civilian Aviation	Education	Industry
Economic	Large and growing amounts of funding (mostly federal) Relatively stable Oligopoly with inelastic demand Lack of price sensitivity -- third party payments Very profitable Growing phase of federal R&D budget	Lack of funds Companies won't invest NILECJ (LEAA) funds -- smoothing Taxes Effect of Recession	Feast and famine Substantial federal funding Oligopolistic airlines and manufacturers Fuel Price Squeeze Major export markets Very big market Technology as a marketable commodity	Lack of funds Comapnies won't invest Reductions Voters defeat school budgets and bond and tax issues Effects of recession	R&D sensitive to state of economy. Dependent on governmental funding in R&D intensive industries. International technological edge eroding in many product lines.
Science and Technology	Rapid rate of change Relatively understood Biological and physical science High specialization	Uneven rate of change Well understood Physical science, biological and systems base Uneven specialization Technology transfer from military is weak Technology transfer from CIA, FBI	Rapid rate of change Well understood Documented physical science based, some biological and social High specialization Cumulative, incremental Few radical Technology transfer very important (from military) Diverging needs Market responsive Technological imperative	Low reliability Uncertain Weak Social science base Low specialization	Wide variation among industries. High technology industries resemble aviation. Low technology: lower rate of change, less integrated R&D system, less linkage to basic science and technology, less documentation, more craft-type orientation.

2. Historical Development

	Health	Law Enforcement	Civilian Aviation	Education	Industry
Degree or phase	Mature	Introductory, especially at local level (rudimentary)	Highly mature, large scale	Introductory	Mature
Age	Up to 1940 Introductory 1940-45 Transitional 1945 Maturity	(Recent)	Up to 1913 Pre-birth 1914-39 Introductory 1940-50 Transitional 1950's Maturity	Up to 1964 Pre-birth 1960's Introductory Approximately 10 years for large scale external R&D Sector is old	To 1890 Pre-birth 1890-1918 Introductory 1918-1945 Transitional 1945-present Maturity
Legitimacy	Few question the value	(Not established)	R&D has the major role High public acceptance of R&D products	Low Not yet established Values are anti-external R&D	Generally high in all major industrial sectors
Articulation/ Evaluation	Disease to health Now hospital/drug/physician Now NIH based Highly specialized but diverse	Poorly delineated	Specialized large companies, NASA, etc. Well defined responsibilities	Unstable funding/personnel base Inadequate knowledge base, standards, information flow. Poor KP-KU integration Lacks many functional specialties	Great specialization in R&D intensive industries - aerospace, electronics, chemical. Specialization also a function of the firms. Evaluation occurs at all R/D&I stages.
Effectiveness	Very	Low	Very	Generally weak/mixed quality outputs	High

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2. Historical Development (Continued)

	Health	Law Enforcement	Civilian Aviation	Education	Industry
ritical eyents	1930 NIH 1935 Title VI, Social Security Act 1937 National Cancer Institute 1941 Committee on Medical Risk WWII successes 1944 Public Health Service Act 1945-55 Major funding increases	Establishment of FBI WWI WWII 1968 Omibus Crime bill NILECJ	1915 NACA WWI WWII 1958 NASA, FAA Korean War 1960's Space Race 1966 DOT 1970 SST 1971 Non-orbiting R&D Support	Mid-to-late 1950's Federal government sponsors research/curriculum development Major expansion of funding 1960's 1954 Cooperative Research Act 1958 National Defense Education Act 1960's Elementary and Secondary Education Act and amendments to Cooperative Research Act creates network of R/D&I institutions; later some labs and centers are dropped 1972 NIE established	1876-Thomas Edison - first industrial laboratory 1900-GE - establish laboratory 1902-DuPont - establish laboratory 1907-Bell Telephone - establish laboratory By WWI-100 industrial laboratories established WWII-Atomic bomb - 1st multi-billion $ R&D project By 1960-5400 industrial laboratories in operation 1957-1969 - Space age technology - lunar landing 1960's to present - diffusion of computer and transition technology.

3. Institutional Base (Network of Institutions)

	Health	Law Enforcement	Civilian Aviation	Education	Industry
Specialization	Universities (medical schools) Federal research institutes Hospitals (medical schools) (private/public) Industry Diversity Fairly large	Diversity (a) Large volume in producers (b) Small volume in federal labs/federally funded labs Hardware In producers and federally funded labs Social/Procedural in 200 universities, agencies, etc.	Extensive university/NASA manufacturing/airlines subcontracting Down to department levels FAA, DOT, CAB	Less functional specialization than in many other sectors Variable	Extensive specialization within and between firms on all phases of R/D&I activity. Basic and applied research supplemented by work done in university and government laboratories
Number of Institutions	Fairly large	Hardware-few Software-many	Few Basic (NASA and DOD) Manufacturing (plus subcontractors) Airlines Oversight	Large number of institutions carrying out R/D&I; relative small number specialized in educational R/D&I	Extremely large; each firm of consequence tends to have its own R/D&I capability
Clusters	Not very linear	Diffused	Linear Parallelism	Looped and adjacent, parallelism Applied research variously clustered with dissemination, with evaluation, and/or with implementation/utilization	Most R/D&I activities tend to be sequential, linear, except in smallest operations
Gaps		Major (Need identification)	None	Major	None in high technology sectors. Variable for lower technologies
Redundancy			Little	Very high	Within firms, virtually none; viewed sectionally-extensive even in oligopolitic industries

3. Institutional Base (Network of Institutions) (Continued)

	Health	Law Enforcement	Civilian Aviation	Education	Industry
Types of Institution	High quality Federal labs Also university based	Large companies Federal labs Universities	Large Formalized	A set of three parallel substreams: 1) Colleges and universities 2) Quasi-public and private sector institutions 3) SEAs, ISAs, LEAs	Private firms dominate. Wide range in sizes of firms.
Cooperation			Common (joint ventures)	Little - some developing	In commercial markets, none among competitors; may contract work to supplier on R/D&I support services. In government markets, may contract or subcontract. In both cases some joint ventures on large projects.
Linkage		Weak		Inadequate Diffuse Lacks formalization and coordination Increased efforts towards linkage	Strong linkage is provided by the market mechanism.

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4. Goals, Policies Strategies

Health

- Create knowledge
- Techniques and products
- Effectiveness rather than cost criteria
- Most users are the health care practioners -- convince them
- Emphasis has been on curing rather than preventing disease
- Influence of external strong
- Death vs. other problems
- Congressmen are influential

Law Enforcement

- Unclear goals of L.E. subsectors
- Diversity of priorities
- Disagreement on value of equipment and systems vs. social issues
- Competition for resources
- Role of NILECJ (ESIP)
- Producer of R&D goals

Civilian Aviation

- Economy, maintenance, noise, pollution, speed, range vs. military performance, payload
- NASA/producers/users spectrum
- Time horizons shorter operations
- Costs go up
- Increasing role of R&D
- Clear specialization
- External environmental effects
  - Energy
  - Environmental impact
  - Costs

Education

- Weak goal setting
- Federal policy goals -- improve education practice and knowledge
- In practice
- Discontinuous shifting priorities
- Inconsistency
- Lack of intermediate goals
- Lack of mechanisms to develop goal consensus
- 1950's and 60's goals set by educational research community
- Mid 60's -- central programmatic R&D
- Short time horizon
- Externally defined
- Emphasis on development, packageable products
- Build regional labs
- NIE increased emphasis on improving practice, dissemination, implementation, utilization building user capabilities

Industry

- Goal setting primarily at the firm and Federal agency level
- Emphasis in either case not on R&D per se. In firms R&D goals derive from corporate objectives and marketing considerations
- In Federal agencies on the agency mission and the perception of national needs
- There is no overall set of industrial R&D policies, or policy making body
- Each sector operates through a complex network of interaction of private organizations, associations and government agencies

5. Administrative Processes

Health

- Dual career paths — administrative/professional
- Funding process generating needs for greater control; therefore, larger proportion of administration
- Health planning becoming recognized specialty
- Projects relatively small, lessening applicability of OR/MS techniques such as PERT

Law Enforcement

- General/research/development
- Sophistication of administration varies with characteristic of L.E.
- Production/marketing/distribution varies with organization
- Acquisition/implementation/utilization/evaluation
- Less variability
- Generally lower level of sophistication
- Barrier to adoption

Civilian Aviation

- Large number of methods specifically for aerospace R&D
- Success may be context related

Education

- Has not been area of major concentration

Industry

- Highly developed techniques to deal with unique problems of R/D&I systems
- In commercial markets these include:
  - Market analysis
  - Technical feasibility
  - Project selection
  - Applied research and development
  - Cost, performance
  - Standardization
  - Operations management
- In government markets these include:
  - More basic research
  - Government procedural controls
  - Frequent shifts of personnel
  - Long lead times/short product life
  - Changing specifications
  - Emphasis on software

6. Personnel Base

Health	Law Enforcement	Civilian Aviation	Education	Industry
R&D	User Organizations	R&D	R&D	R&D
Personnel in research located throughout R/D&I system	Labor intensive	Large numbers of science and engineering and other highly developed skills	Small overall base	Varies by sector according to size and level of technology.
Large proportion professionals	Personnel is obstacle to innovation adoption	Skill mix and concentration critical	Concentrated in research, development and evaluation	Federal funding supports high ratio of scientists and engineers in space and defense related industry. Private funding in other industries, especially large, risk industries-oil, motor vehicles. Low technology industries hire few R&D types.
Professionalism found at KP and KU ends of R/D&I process	Greater specialization	High rate of obsolescence of skills	Inadequate in dissemination and implementation/utilization	High specialized R&D manpower pools in all major industries. High status and career opportunities for R&D personnel.
Professionalism through certification formalities, impedes reserch	Can lead to greater adoption rates	Research labor levels fluctuate with economic condition	Research orientation derived from academic project research rather than program development.	
		Mobility high within sector	Inadequate supply of R&D managers	

7. Funding

Health

Sponsorship (1973)

- -Federal - 60%
- -Industry - 30%
- -Foundations - 5%
- -Voluntary health agencies - 5%

3.5 billion

Federal funding dominant in basic and clinical research

Medical profession dominates the influence on allocations

Law Enforcement

User organizations

Political processes impede adoption

Budget levels and processes impede adoption (budget primarily labor-intensive)

Federal funding dominates expenditures by user organizations

Research organizations

No incentive to use federal funds due to lack of assurance of proprietary results

Private funds not encouraged by perceived characteristics of the market

Civilian Aviation

Federal government dominant source of R/D funds

1958-1968

Federal - 5 billion, a year

Private - ½ to 1 billion

Long time span from research to $ return

Education

Federal government primary sponsor

4 weaknesses:

- -concentration of sponsorship
- -amount of $
- -diffusion of expenditures over broad spectrum of projects
- -instability

Smaller percent of Gross National Product than other sectors

Industry

1953-1970 R&D expenditures increased 10% annually, and as a percentage of GNP, from 1.4 to 2.7. Recent decline beginning 1966 to present

Federal spending in 1972, $8.05 billion out of $19.2 billion in industrial sector

Federal funding varies by sector: over 90% in aircraft, 60% in electrical equipment, and 40% in instrument industry

Only in chemical and allied products and petroleum is basic research over 10%

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8. Information Flow

Health	Law Enforcement	Civilian Aviation	Education	Industry
Open-free-extensive **Problem: overload**	Lateral transfer at user and research levels Less from research to user User organizations - informal Periodicals important	Research level free and easy Development/production is proprietary	3 information systems - R&D --> R&D - user --> user - external R&D --> user All weak and insufficient Media Annual meetings Publications Not enough informal nets Each system has barriers No policy or interventions directed at info-transfer improvement	Well developed network of information services available and utilized, both in-house and externally by most firms Each firm also has systems of proprietary information Information sources include specialized documentation and information services supplies, vendors, industrial associations, technical publications, and a network of experts

9. Innovations

Health	Law Enforcement	Civilian Aviation	Education	Industry
Trend towards increasing costs. Varies from simple to highly complex However, the more technologically complex the innovation, the more likely is adoption (in larger hospitals)	Products must be differentiated by function within the system Police/courts/prisons more detailed Usable typology needed	Visible innovations tend to come in very large costly products but there are also many hidden incremental improvements to existing equipment and support systems	Products that go through a formal process of development have high development costs; less expensive for practice based development "People-change" products - implication for implementation (product/user reactiveness)	Innovations vary from minor changes to major changes, extension of state of arts, new product with new function, and breakthrough Innovations increasingly are initiated and developed in corporations Innovation rates in sectors vary considerably based on R/D&I effort required, state of arts of relevant technologies and user requirements

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10. Need Identification

Health

- Need for research is a constant need
- Potentials stressed more than needs
- Not-for-profit exploration in developing new treatments
- For-profit firms concentrate on greatest consumer use
- Process for need identification is surveying the providers of health care and noting characteristics of consumers.
- Emphasis on effectiveness more than on efficiency.

Law Enforcement

- Anyone can
- Not performed uniformly by users
- Both product availability and problems affect process
- But self-evaluation by departments is weak
- External pressures often spark needs
- But L.E. departments resist external pressures
- Producers need identification unique or specific request
- Little market research (except 2-way communication)
- Outsiders find it hard to need identification-don't understand operations

Civilian Aviation

- Producers stimulate user needs (as well as need identification)
- Airlines stimulate consumers
- Aircraft close contact ultimate public

Education

- Weak
- Mostly episodic, tuned to funding
- Scattered throughout R/D&I
- Lacks formalization
- Intuition
- Opportunistic
- Little data-based, but increasing
- Very little translation into specific R/D&I requirements
- Vague statements
- Unable to create integrated KP/KU perspectives

Industry

In the commerical sector, firms respond to user requests for a good or service, or to competitive pressures which necessitate a product or service improvement. They also generate needs by developing and offering new products or services. In the government sector, needs are primarily identified by the Federal agency, but at times by the firm.

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11. Generation/Research

Health

Biological science but also physical sciences coming in and social sciences
Total system of health (holistic)
Lab and field (increasingly)
High technology equipment
Lack of integration across segments of the field; variety of settings; usually animals

Law Enforcement

Great variety of technologies
Problems with Technology transfer widely dispersed from military
Federally funded labs not taking place.
Very little role for University in hardware

Civilian Aviation

Science based
Fundamental
Physical sciences (University), NASA, DOD
Laboratory and field research
Large scale facilities
Teams (large)
Accumulation of detailed advances
Fast publication
Mission oriented
Excellent research
Environment
Product and program matrix organization
Research stops at prototype stage.

Education

Relatively small amount of education practice is based on research; is rather more intuitive
Poor definitions of questions
Low rigor; inadequate grounding in theory
Methodology issues
Problems:
Cooperation between disciplines
Determination of priorities receives relatively little support
Ethical issues
Control of research autonomy
Mostly field research
Research moving out of university

Industry

Ideas originate primarily in the R&D lab, marketing, or market research
They are developed in the R&D lab, either through search or research
Team efforts predominate as does applied research over basic

ERIC

12. Development

Health

Done on human patient
Side effects
Done in hospitals
Welfare patients
Pilot testing

Law Enforcement

Difficulties in commercialization impede development
Important potential role of small producers

Civilian Aviation

Most complex
High cost
Prototype
Critical stage
Not always clear output
Complex multi-department process
Ends with flight testing
High technology transfer from military
Cultural aspect

Education

(a) Use the engineering model in formally defined development
(b) But lot of informal
(c) Follows formal sequential steps to field
Large scale, expensive projects
Much practice-based development; not rigorous development model; little field testing; little systematic evaluation; often not packaged for generalized usability; less expensive

Industry

Characterized by emphasis on reduction of risk and uncertainty due to high costs and long work cycles; cost and time overruns in both the government and commercial sectors; and parallelism and overlap of project components through scheduling to reduce completion time

13. Production

Health

Production considered as:
1) manufacturing supplies & equipment and,
2) providing services directly to consumer

Quality primary concern of production - more than cost or price

Several sources of quality standards and evaluation:
1) FDA
2) Department of Commerce
3) Professional Standards Review Boards
4) American Hospital Association

Law Enforcement

Producers generally cautious about making commitment to L.E., especially for innovations

L.E. market size may be suited to small producers to match the limited production facilities, bu the distribution requirements exceed small firms capabilities

Production standards not so important

Very few production standards or specifications for most product areas

Most producers of L.E. innovations are in L.E. as a secondary market

Civilian Aviation

Production is in custom-shop environment

Production control is customer oriented in design adaptation, delivery, etc.

Long lead times involved in production scheduling

Production of major product (airplanes) involves one prime producer & many subcontractors for subassemblies and subunits

Quality control of central interest

Complicated by complexity of production and assembly processes

Education

Most producers of education products are not primarily education oriented (similar to L.E.)

Production not a major issue area in education

Production capabilities (printing, etc.) readily available

Industry

Dominance of mass production systems determined organization and management techniques through World War II. Emergence of science based high-technology firms with limited production emphasis in post WWII era. Unit or small batch processing tends to be development oriented; large batch and assembly line, is production oriented; and continuous processing, is marketing oriented.

14. Marketing/Distribution/Dissemination/Diffusion

Health

- Health industry has experienced growth, no prospects for short-range drops in growth rate.
- Increased risk-avoidance may put greater pressure on prepurchase testing and evaluation
- Changes in goal-orientation of medical practice from corrective to preventive feeds back to producers in form of new needs and requirements and possibly, in marketing strategy
- Drug marketing relies on personal contact with physicians by "detail user"
- User almost exclusively dependent on producer for information
- Producer provides both the information content and the information dissemination function
- Large hospitals are the innovations and early adopters

Law Enforcement

- Market highly fragmented in size variability and goal orientation of users
- Fragmentation impedes entrance of new producers into the market
- Producers do not (generally) find it economically feasible to sell exclusively to L.E.
- Many different distribution channels exist
- Differences are often product-specific
- Information passed on informally, especially from large to small users
- Process not well institutionalized
- Requires considerable initiative on part of small users
- Diffuse purchasing process presents formidable complicating picture to potential suppliers
- Labor intensive-very small percentage of user budget goes to equipment

Civilian Aviation

- Market as a whole, characterized by growth
- Users relatively sophisticated customers
- Individual users highly variable in adoption behavior in timing, creating fluctuations
- Market needs segmented creating hanging needs for innovative products
- Close customer contact by producer sales personnel required to generate interest and commitment to justify production of innovative products.
- User commitment must precede investment in production
- Innovation adoption aided by ability to dispose of functional current products with after-market

Education

- Function includes: dissemination/diffusion, marketing, distribution
- Overall impact on system: weak
- All receiving current interest by sector planners and policy makers
- Dissemination activity shifted from transferring of bodies of knowledge (research results) to information about packages products or developed practices.
- Information dissemination aided by ERIC for researcher; less helpful for practitioner
- Federal funding supported organizations directly involved in information dissemination
- Current NIE interest in dissemination aimed at up-grading user adoption behavior. Strategy is: proactive, interpersonal, user-oriented, field-based network

Industry

- Marketing is the focal point of industrial innovation. Markets exist in all phases of product life cycle. In general, consumer markets are highly saturated and subject to product modification and differentiation, not basic changes. Occasional introduction of major new products.
- R&D highly sensitive to market requirements; elaborate organizational and management techniques to insure continuous monitoring, evaluation and feedback. Emphasis on risk reduction due to high product mortality rate.
- Industrial marketing makes extensive use of technical personnel to work with clients, determine requirements, provide technical information and assistance.

Health	Law Enforcement	Civilian Aviation	Education	Industry
Market characteristics for diffusion of innovative equipment is not well understood		Political and economic environment of the sector important factors in the adoption process	Distribution system undeveloped	

15. Acquisition

Health

Concentrates on hospitals in acquiring new technologies
4 factors affecting acquisition decision
1)needs of local population
2)present services structure
3)status
4)availability of funds
Status a major factor
Funding generally available-controlled by state planning agencies
Large hospitals are the innovators
Little is known about the adoption decision process in the hospital
Standards for equipment are well articulated and regulated
Increased risk-avoidance by purchasers (hospitals and physicians) will emphasize pre-purchase test and evaluation

Law Enforcement

Activities included:
1)pre-purchase evaluation
2)testing
3)selection of specific product
4)purchase decision
User agencies lack resources and technical capabilities for pre-purchase testing and evaluation
Specialization of function (e.g.: communications) tends to improve evaluation
Standards are generally lacking for equipment where they exist, they make evaluation more effective (e.g.: communications)
Purchasing tied to bidding thereby requiring standards for specifications
Bidding also places great emphasis on price or cost
The purchase decision is based more on administrative and financial factors than technical
Purchasing also complicated by being integrated with purchasing function of other governmental agencies, such as fire, street, etc.

Civilian Aviation

Search for innovations (new airplanes) is well articulated function-held to be a critical function
Pre-purchase evaluation and testing well established as process activities
New aircraft adapted for both
1)optimal fit with present operations
2)develop competitive edge as "launching purchaser"
Sophisticated buyers
Cost of new airplanes and systemic effects of adoption are forcing process to be even more critical and analytical

Education

Acquisition functions virtually non-existent as institutionalized activity - not an articulated and assigned responsibility
No systematic link between suppliers and potential users
Very little evaluative information regarding available products
Quality control not well exercised
Standards generally lacking
"Potential targets" for acquisition decisions must be better defined-teacher, principal, curriculum specialist, superintendent, or community interest groups
Some evidence suggests linkage to external resource systems are important factors
NIE proaction -
1) Consumer information unit
2) R&D utilization unit
3) Development of catalogs of available products; funding programs to provide evaluation information
4) Funding organizational development and other projects to upgrade user ability to adopt innovations

Industry

Acquisition processes vary by market type-government, industrial, institutional, and consumer. Government and institutional markets have more complex acquisition procedures - highly bureaucratized, long delays.
Wide variations in producer-user interface characteristics based on relative level of technological development, scope of contrast, and area negotiates. Result is a variety of mechanisms to offset producer-user interface gaps
The critical acquisition skill varies with the industry sector: in aerospace, concept definition; in building construction, procurement and scheduling; in retailing, quantity and cost negotiations; and in steel making, acquiring new sources of raw materials.

16. Implementation and Utilization

Health	Law Enforcement	Civilian Aviation	Education	Industry
Highly skilled user population Professional vs. administrative staffs affect implementation Differentiated adoption characteristics of large vs. small user organizations (hospitals)	User problem low level of technological sophistication Producer assistance minimal-too risky, given low potential for sales.	Implementation has effects throughout the user system and in all phases of the organization Barriers: -customer acceptance -political/legal constraint -user structural or technological barriers -cost	One of most neglected functions in educational R/D&I Discrepancy between adoption rate and use of innovations Caused by: 1) User norms and resistance 2) Lack of technological sophistication necessary to implement More known about 1 than 2 Linkage organizations have evolved - helping educational organizations become more adaptive	Implementations activities are characterized by a high level of development of product organization activities to assist users. Industrial users are best geared to accepting innovations; governmental and institutional users are less effective. Consumer markets form an organization-individual interface.

17. Support Services

th

st always avail-
le
cost-sensitive
ort services are
ncentrated within
e sector itself
n hospitals,
search, phar-
ceutical com-
nies, equip-
nt suppliers).
ry little other
pport from
urces external
these groups

Law Enforcement

General sources: Federal agencies
L.E. professional associations
Outside consultants
Need ID: some by users -- more by producers
Generation/Research/Development some efforts of direct subsidy from Federal agency to encourage entry of new firm
Generally lacks adequate supporting function
Production
Most producers are support oriented
Marketing/Distribution
IACP supports by "equipment listing" distributions; support is passive.
Implementation and Utilization
Relatively unsupported university institutes support manpower development
Evaluation
L.E. associations support development of standards
Outside consultants directly evaluate or up-grade in-house evaluation

Civilian Aviation

Some support functions: -sub-contracting for components, equipment, and urgent services
No information on extent to which these organizations are in or out of the aerospace sector

Education

Equipment service organizations
Printing and publishing organizations
Survey research organizations
Relatively little published literature about support functions

Industry

Full array of support functions available in all industrial sectors
Internal support activities include test laboratories, technical publication services, technical library and information services, drafting and computer services
External support activities include above services on commercial basis; also supplies and government laboratories, contract research institute, laboratories of industrial trade associations and cooperatives, consultants and consulting engineers

18. Evaluation Research

Health	Law Enforcement	Civilian Aviation	Education	Industry
Evaluation criteria effectiveness-oriented rather than cost or efficiency oriented Evaluation standards vary at different stages of the R/D&I process	Evaluation not a prime characteristic of users Lack of standards and skill level of user personnel prevent development of evaluation as an effective function.	Equipment evaluation methodology fully developed - high credibility, rigorous standards, substantial control by federal agency	Most rapid advance of all educational R/D&I function in last 10 years Federal funding demanded evaluation-generating specialization of evaluation Specialization takes place in private sector as well as academia Methodology one aspect of specialization Evaluation research knowledge becomes more sophisticated Evaluation research function has acquired increased political decision making influence; still not widespread as basis for decisions In spite of the development, evaluation research function still in growth phase Evaluation methods and credibility based essentially on social science methodology	Systematic evaluation at all phases of R/D&I system. Initial evaluation and selection results in reduction of candidates ideas, proposals or projects. Many formalized R&D project selection techniques Mission oriented evaluation techniques are based on agency performance criteria; market oriented techniques identify innovations capable of producing income

19. Research on R/D&I

Health	Law Enforcement	Civilian Aviation	Education	Industry
Little or no research on health R/D&I Some descriptions of components but data are not comparable.	Very little - just beginning	No previous descriptions of overall R/D&I system Systems and techniques for management of R&D	Much analysis and research because: 1) Negative political climate 2) Self-consciousness of social sciences in 60's 3) International influence 4) Sponsors' interests in evaluation research for policy formation. Much literature but: 1) Directed at segments of the system 2) Relatively little empirical data 3) Atheoretical 4) Little used	Industrial R&D is the major source of current research management literature Theoretical, empirical and wisdom literature developed covering all major topic areas Most research-on-research management initiated to cover/large-scale high technology sectors Defense and space industries required development of new planning, organizational, procurement, and control techniques

SECTION THREE

ILLUSTRATIVE CONTEXTUAL ANALYSIS OF SELECTED FEATURE ISSUES

CHAPTER SIX

INSTITUTIONAL BASE: THE NETWORK OF INSTITUTIONS

ERIC

INSTITUTIONAL BASE: THE NETWORK OF R/D&I INSTITUTIONS

I. OVERVIEW OF THE INSTITUTIONAL BASE FEATURE

II. DETAILED SUB-ISSUE ANALYSIS: R/D&I SYSTEM STRUCTURE AND INSTITUTIONAL ROLES IN THE R/D&I SYSTEM

1. Narrowing the Focus of Analysis: Specialization and Configuration
2. An Initial Analytical Analysis of Specialization and Configuration
3. Clustering of R/D&I Functions as a Focus for Analysis
4. An Initial Contextual Analysis of Clustering in Relation to Three Contextual Features
5. Selecting a Set of Clustering Dimensions and Contextual Conditions for Detailed Analysis
6. Developing a Detailed Analysis of the Clustering Issue
7. Scenario Case Analyses of Emergent Clustering Resulting from Different Contextual Determinants

   i. Case A
   ii. Case B
   iii. Case C
   iv. Case D
   v. Case E
   vi. Case F

8. Initial Analysis of the Implications of Contextual Determinants of Emergent Clustering for Management/Policy Strategies
9. Detailed Analysis of the Implication of Contextual Determinants of Emergent Clustering for Three Selected Areas of Management Concern

FIGURES:

MATRICES

CHAPTER SIX

INSTITUTIONAL BASE: THE NETWORK OF R/D&I INSTITUTIONS

I. OVERVIEW OF THE INSTITUTIONAL BASE FEATURE

A discussion of R/D&I institutions (i.e., the organizations in which the various stages of the R/D&I process occur) could encompass the totality of issues with which a researcher or policy maker might be concerned. In our case, however, we use the totality of features in a contextual analysis to provide such comprehensiveness. Thus, the institutional base feature focuses in on R/D&I system structure and process (i.e., the network of institutions). Why is it, for example, that R/D&I systems exhibit differences in their structures, the type and roles of the institutions involved in the system network, and the character of the relationships between the constituent institutions? To be more specific, why do we observe in some contexts a very extensive division of activities with considerable specialization of roles and in others we observe a much higher level of role integration within multi-purpose institutions? In some cases the institutions in the system seem to be linked together in a neat set of linear relationships, with each institution being responsible for a well-defined set of steps within the R/D&I process and with these then handing programs on to the next stage. In others we see loops, recycling, institutions that combine idea generation and implementation yet not development, and so on. Why is cooperation between institutions common in one context but rare in others? It is to such institutional network issues that this section is devoted.

There are five main issue areas which must be analyzed in order to gain a comprehensive understanding of the institutional base feature:

R/D&I System Institutions:

1. What are the role functions of the various institutions within the R/D&I system?

2. What are the characteristics of these institutions?

R/D&I System Structures:

3. How are the R/D&I functions structurally configured (clustered) within the R/D&I system?

4. What are the inter-institutional linkages within the R/D&I system?

5. What are the characteristics of structure of the R/D&I system?

Additionally, of course, we will want to identify which institutions form the institutional base of the R/D&I system. Figure 7 summarizes and expands these five main areas.

In analyzing the role functions of the institutions within the R/D&I system, the objective is not to detail the tasks performed in each of the R/D&I functions (e.g.: the development function). This is done in analysis of other features. Rather, the objective is to deal with such questions as: In which institutions do we (or should we) find development work going on? Is it in the knowledge producing, distributing or user organizations, or in some combination of these (and whether in a differentiated or duplicative and redundant manner)? To what extent do we find institutions specializing in one or more of the R/D&I system functions (for example, see Figure 8). We would also wish to know which institutions are part of what we could call the R/D&I superordinate system (providing system resources and constraints and accepting system outputs), the R/D&I coordinate system (part of or parallel to the R/D&I system), or subordinate systems (institutions providing support

Figure 7

Institutional Base

(Network of Institutions)

Institutions

Institutional roles within the R/D&I system

Specialization of institutions

Research/engineering/development/production, etc.

Role in superordinate/coordinate/subordinate systems

Sector spanning institutions

Institutional characteristics

Internal structure

Configuration

Integration

Centralization

Formalization

Articulation/visibility

Stability

Internal processes

Decision making

Communications

Authority/status

Cooperation

Dimensions

Size

Status

Level of maturation

System Structure

System configuration (clustering) of R/D&I functions

Linearity

Parallelism

Looping/contiguousness

Continuity/gaps

Redundancy

Inter-institutional linkages

- Linkage characteristics
  - Strength
  - Permanance
  - Formality
  - Directness/mediatedness
  - Visibility
- Interface structure/liaison mechanisms
  - Boundary conditions
    - Open/closed
    - Fixed/variable
- Linkage consequences
  - Functional/dysfunctional
  - Cooperation/conflict
  - Joint ventures
- Characteristics
  - Centralization
  - Formalization
  - Diffuseness
  - Stability
  - Visibility
  - Appropriateness
  - Balance

services); whether institutions perform multi-systems level roles (e.g.: providing both resources and support services); whether institutions are sector-spanning (providing services to several fields -- e.g.: education and health); whether in a given context the institutions are specialist or generalist (with respect to R/D&I functions).

In analyzing the characteristics of the institutions within the R/D&I system, we would want to know about their internal structures (type of configuration, degree of centralization and formalization, etc.); about their internal processes (decision making, communications, authority, status, etc.); about various dimensions such as size, level of maturation or development, etc.

In the process of analyzing the structure of the R/D&I system, we will want to know whether the structural configuration of R/D&I functions is characterized by linearity, parallelism, looping, clusterings of R/D&I functions (which functions?), redundancy, etc.

In the process of examining the structure of the R/D&I system, we will also want to understand how the institutions are linked together. We would want to know which institutions are linked to which other institutions. We would be concerned with whether the links were srong or weak, permanent or temporary, formal or informal, direct or mediated, cooperative or conflictive. The nature and quality of these linkages and interfaces, and the boundaries across which they occur are of central importance.

In analyzing the characteristics of the R/D&I system's structure, we will be asking such questions as: Is the system's structure centralized or decentralized? To what extent is the system's structure formalized? Is the system's structure well articulated and stable throughout the system or is it diffuse and changing?

In Figure 8, we provide two illustrative examples of how R/D&I system might be concretely structured. As these examples indicate, we do not assume either that all R/D&I systems will be structured similarly or that all R/D&I systems are "complete".

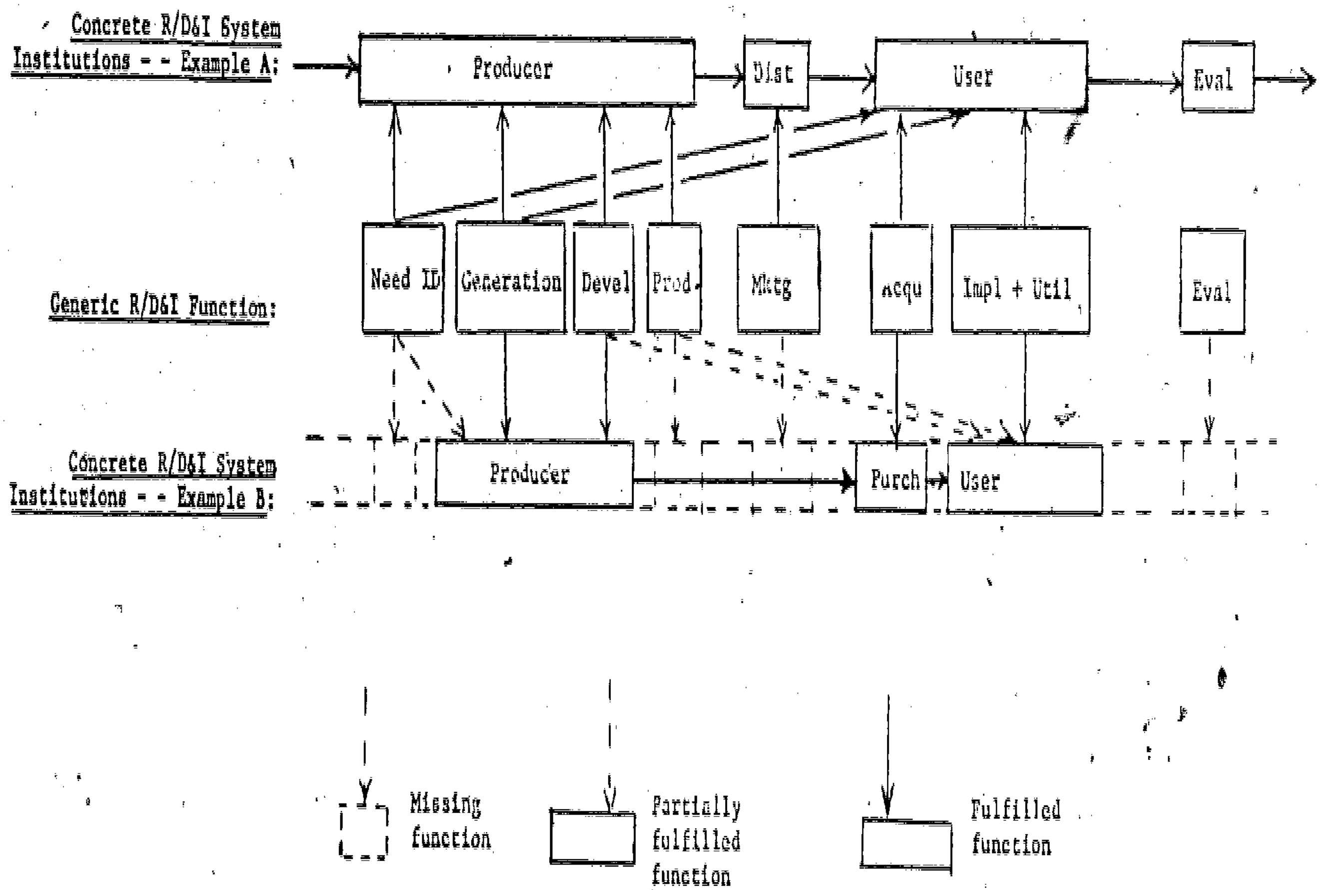

Figure 8

Examples of Intra-System Structures

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In example A, we find an integrated producer performing all the generic functions from need identification through production. Marketing is handled by distributors (jobbers). Purchasing, implementation and utilization as well as participating in need identification and generation are user institution functions; and evaluation is carried out by an independent organization (e.g.: federal government). This might describe some aspects of the hospital equipment field.

In example B, producers have only weak linkage to user needs and work only up to the development stage. Prototypes are purchased by an organization that is separate from the users. This happens, for example, when city governments centrally purchase for their operating units (e.g.: police or fire departments). Evaluation may be virtually non-existent. In fact, this process describes our findings in a recent study of the innovation process in law enforcement equipment - - with special reference to voice identification equipment.(2)

We now turn to more detailed illustrations of how our contextual analytical framework can be utilized in relation to various feature issues. To do this, we have narrowed the focus of our analysis by selecting sub-issues from among the list of issues in Figure 7.

II. DETAILED SUB-ISSUE ANALYSIS: R/D&I SYSTEM STRUCTURE AND INSTITUTIONAL ROLES IN THE R/D&I SYSTEM

1. Narrowing the Focus of Analysis: Specialization and Configuration

In this detailed sub-issue analysis, we have chosen to focus on the R/D&I functions. To sharpen this focus further, we have selected two sub-issues: specialization of institutions (with respect to the R/D&I functions) in relation to the emergent structural configuration of the R/D&I system (in terms of the R/D&I functions). In the "configuration" sub-issue, we are specifically interested in how the R/D&I functions are clustered (i.e., Environment of the R/D&I System

Historical Development

Institutional Base (Network of Institutions)

Goals, Policies, Strategies

Administrative Processes

Personnel Base

Funding

Information Flow

Innovations

Need Identification

Generation/Research

Development

Production

Marketing/Distribution/Dissemination/Diffusion

Acquisition

Implementation/Utilization

Support Services

Evaluation Research

Research on R/D&I

Institutional Base (Network of Institutions)

Institutions

Institutional roles in the R/D&I system

Specialization of institutions

Role in superordinate/coordinate/subordinate systems

Sector-spanning institutions

Institutional Characteristics

System Structure

System Configuration (clustering) of R/D&I Functions

Inter-Institutional Linkage

Characteristics

Figure 9

Selection of Institutional Base Sub-Issues for Focused Analysis grouped together) in the various institutions. This dual perspective (specialization and configuration) of the institutional base of the R/D&I functions should provide a rich base for analysis. The process for narrowing the focus of the analysis to these two sub-issues is illustrated in Figure 9.

2. An Initial Analytical Analysis of Specialization and Configuration

We are now ready to begin our first attempt at contextual analysis for the institutional base (network of institutions) feature of the R/D&I context. The question at this point is: Do we observe, (as we look across various contexts) differences in the way that institutions operating in the R/D&I system specialize in various R/D&I functions (from need identification to utilization and evaluation research) and in the way in which these R/D&I functions become clustered in the emergent configuration of the R/D&I system? This is shown in Matrix 1 in which the specialization and configuration variables are interacted with each of the contextual features.

As always, there are interaction effects between the various features in terms of their impact, as well as second order issues. For example, Matrix 1 enumerates a whole complex of contextual requirements which will lead to the configuration of the system network taking the particular form that it might in any specific case (thereby moderating the generic requirements). But the emergent configuration itself, immediately and over time, generate a source of continuing variance. Thus the configuration may generate interface issues requiring management and policy actions. Depending on how these management and policy options are exercised, there will be a feedback influence on the configuration of the system. One example would be the creation of liaison mechanisms to help overcome interface problems and sometimes leading to the appearance of actual liaison institutions in the network of institutions. Another example has been the emergence of business incubator departments and organizations whose specific role is to overcome the interface difficulties that are common in the R&D to commercialization linkage. This general issue is diagrammed in Figure 10.

ERIC

MATRIX 1

BRIEF ILLUSTRATIVE CONTEXTUAL ANALYSIS OF

TWO ISSUES OF THE INSTITUTIONAL BASE FEATURE

Contextual Feature	Specialization	Configuration
1. **Environment** Political/Legal Processes	Regulations creating and restraining specialties, various innovations	Regulations, policies creating and restraining institutions
Social/Cultural Processes	Norms favoring/restraining specialties	Norms favoring/limiting certain types of institutions/relationships
Economic Factors	Differential expenditures in specialties. Economic control of specialties	Differential expenditures by types of institution Economic control of institutions
Scientific/Technological Factors	Impact on state of arts Type of knowledge base certainty, science/craft Technological imperative effects	Effects on economics of scale and interface costs Sunk cost effects
2. **Historical Development** Institutionalization	How do specialization patterns change as a field becomes institutionalized (in general and within specific organizations)?	Are there particular configurations more or less congruent with various phases of institutionalization?
Critical Events	Legal events that create specialties (needed to meet certain regulations). State of the art events that create new specialization. Funding becomes available for particular specialties.	Legal requirements for certain institutional arrangements/relations. Establishment of specific institutions. Establishment of specific cooperative relationships
Time Effects	Maturation of specialties Paradigmatic revolutions	Organizational aging leading to organizational growth and decline Development/decline of inter-organizational relations

Contextual Feature	Specialization	Configuration
3. Institutional Base (Network of Institutions) (other factors only)		
R/D&I Institution Characteristics	Impact on ability of certain specialties to flourish Distribution of specialties	Effects on ability and willingness to interrelate and cooperate
4. Goals, Policies, Strategies		
Strategy Development		Vertical and horizontal integration strategies
5. Administrative Processes		Management of institutional interfaces
6. Personnel Base	Effect of career patterns, and professionalism of personnel Effect of obsolescence	
7. Funding		
Constraints on use	Effect of allocation of funds for specific specializations	Support for specific institutions and and networks
Capital Requirements		Effects of economies of scale, and cost of facilities
8. Information Flow	Effect of information availability on appearance of specialties	Information distribution in the network of institutions
9. Innovations		
Requirements	Effect of state of art requirements Legal/regulatory/social constraints	Effect of level of R&D effort required
Characteristics	Effects of product/process life cycle and testability	Effects of product/process life cycle, cost, scale on types of institutions involved in network.

Contextual Feature	Specialization	Configuration
10. Need Identification Process	Effects of technology gaps	
Need identifiers	Specialization required	Appearance of specialist need identification institutions (e.g. market research)
11. Generation/Research	Specialization required	Institutional environment and network required
12. Development	Specialization required Role of specialized incubator and spin-off organizations	Institutional environment and network required (plus effects of pilot plant requirements)
13. Production	Specialization required for productivity	Institutional environment and network required (plus effects of economies of scale)
14. Marketing/Distribution/Dissemenation/Diffusion	Specialization required	Institutional environment and network required (plus effects of market structure and innovation diffusion)
15. Acquisition	Specialization required	Institutional environment and network required

Contextual Feature	Specialization	Configuration
16. Implementation/Utilization	Specialization required	Institutional environment and network required
17. Support Services		
18. Evaluation Research	Specialization required	Institutional environment and network required (plus effect of need for inadependent evaluation in some cases)
19. Research on R/D&I		

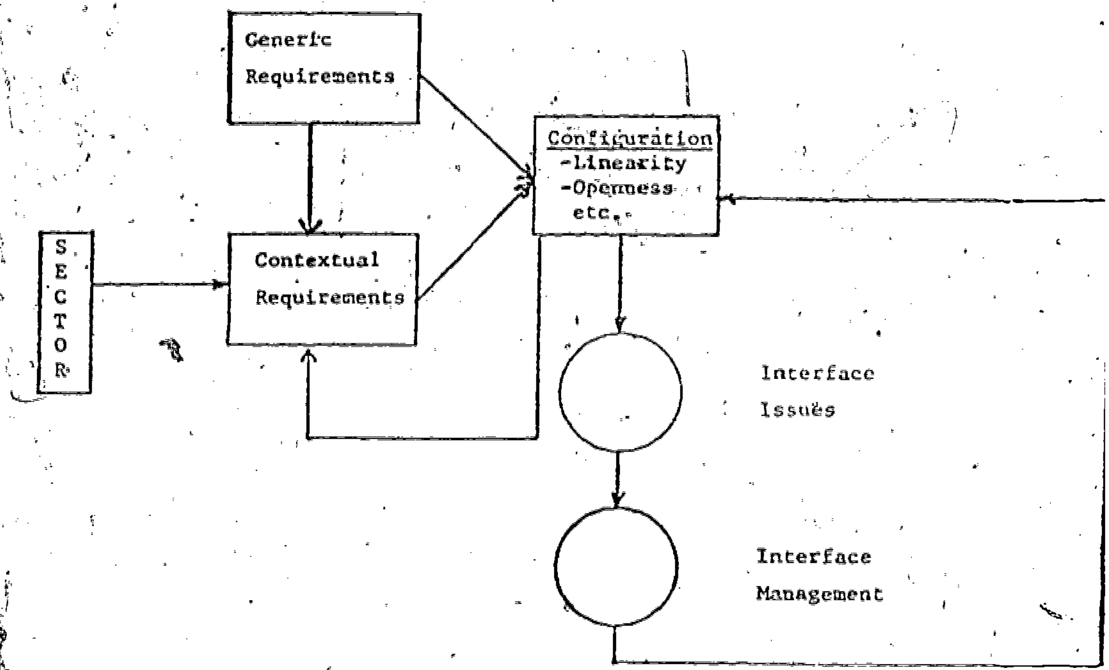

Figure 10

Relation Between R/D&I System Issue (Configuration), Sub-Issue (Interface) and Management Actions

Another interaction effect of some relevence is that between technology and institutionalization (i.e., relating the environmental and historical features). In some of our own recent research(3) we have demonstrated how an increase in the scale and investment in experimental technology can act to further the institutionalization of a field of science (in that case high energy physics) defined in terms of its industrialization, bureaucratization and shifts in professional norms from cosmopolitan to local values. Such phenomena would be related to the "technological imperative" and "sunk cost" effects already noted in Matrix 1. By such concepts we refer to the hypotheses which see scientific choices and specializations as being driven by the demands of the in-place technologies of experimentation, whether by its inherent constraints or by philosophies requiring exploitation (and/or amortization) of previous investments in technological facilities and equipment.

Returning to the Matrix 1, it is evident that the historical and environmental features of context would be a starting point of rich potential. Examination of the issues to be found in these areas indicates the centrality of such questions as the nature of the state of the arts and the legal/economic/social norms. In the light of our discussion above concerning specific interdependencies between features, it would therefore appear necessary to connect any consideration of the impact of historical and environmental context on specialization and configuration with a consideration of the professional skills and norms of the personnel involved in the process. The question of skills required for specialization can be seen to be a pervasive issue in this analysis. In selecting, therefore, a narrower area for comparative analysis we focus in on the subset of Matrix 1 area represented by the above features.

3. Clustering of R/D&I Functions as a Focus for Analysis

Further, as another simplifying step in the analysis it would be helpful to attempt to link the twin dependent variables of specialization and configuration. The question is: How do various patterns of specialization reflect themselves in the configuration patterns of R/D&I systems? Another way of stating this question is: How do the various specialties cluster together within specific institutions in the R/D&I network, hence generating the emergent configuration? In practice, of course, we do not encounter a near infinite variety of institutional forms each with its own cluster of specialties. For most practical purposes the clustering with which we are concerned is at the more macro level of the R/D&I functions that we (and most others) have described as "development", "production", etc. -- although it is to be borne in mind that a specific specialty that is to be found in "research" in one context may well be found in "development" or "implementation" in another. However, for our purposes, at least in a first analysis, it is reasonable to concentrate on the question of how the R/D&I system functions are grouped together (clustered) in the network of institutions. "Clustering" is an issue that captures much of the specialization issue. It now becomes the focus of our continued analysis.

MATRIX 2

Initial Detailing of Questions Relevant to the Clustering Sub-Issue in Relation to Three Contextual Features

Contextual Feature	Clustering
1. **Environment**	
Political/Legal	Are there any political/legal determinants of clustering of R/D&I functions (e.g.: legal requirements that basic research must be controlled by professional practitioners, i.e., professional regulation)?
Economic Factors	Has there been any pattern of economic support that has permitted certain R/D&I institutions to grow and absorb functions previously performed elsewhere (or not at all)? Has the overall level of economic support permitted the full development of R/D&I system functions? Have the sources of economic support legislated the clustering of functions for reasons of economic control and cost efficiency?
Scientific/Technological Factors	How does the nature of the knowledge base (state of arts) determine the emergent clustering patterns (e.g:, the effect of the ability to codify the knowledge on interface transfer difficulty)? Does increasing certainty of knowledge permit greater specialization? Are craft (as opposed to science) fields more or less likely to exhibit detailed specialization and differentiation of R/D&I system functions into separate institutions? What types of technology provide opportunities for economics of scale and how does this weigh against interface costs in determining functional clustering?

2. Historical Development

Institutionalization	What is the relationship between the level of institutionalization of an R/D&I system and the way in which R/D&I functional specialties are clustered in specific institutions? Is there a tendency towards more specialization with maturation? What is the effect of institutionalization on the evaluation process?
Critical Events: Legal/ Political	Have there been any specific legal/ political events requiring (or forbidding) specific clusters of functional specialties?
State of the Art	Have there been any state of the art developments that have significantly modified the nature of the various R/D&I system functions and hence how they are clustered together in institutions?
Time Effects	How has any gradual change in the nature of the fields of knowledge influenced the way the specialties operate and interrelate between each other (for example through increasing codification of the knowledge base)? Have patterns of cooperation emerged over time? What is the impact of institutional growth and decline on the clustering of R/D&I system functions?

6. Personnel Base

How do professional norms, career patterns, etc. determine the combinations of specialties that are found in the field with consequent impact on the clustering of R/D&I functions (e.g: do the users insist on participating and even controlling the knowledge generation process)? How is the flow of personnel into and out of fields affecting the viability of specific institutions and hence the clustering? What is the effect of differential obsolescence of personnel in various fields? What is the effect of personnel in some parts of the R/D&I system being only partially committed to their specific functional roles (e.g.: part-timers or having multi-function concerns)?

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4. An Initial Contextual Analysis of Clustering in Relation to Three Contextual Features

Matrix 2 develops our analysis around the focal issue of clustering. In Matrix 2, we become somewhat more specific on the issues than in Matrix 1 -- but we now concentrate only on the historical development, environment and personnel base features of the context as they impact the clustering of R/D&I functions.

Examination of Matrix 2 would indicate that the three contextual features (environment, historical development and personnel base) are being operationalized under a number of main areas. These could be consolidated as follows:

1. Effect of the institutionalization of the field of knowledge and knowledge application.

2. Legal/political/social/economic regulation.

3. Political/social/economic support for various institutions and functions.

4. ~~Effects of technology.~~

5. Nature of the knowledge base (state of the art).

6. Effect of the maturation of specialties.

7. Professional characteristics of personnel.

The above could be consolidated further into issues concerning:

1. field of knowledge and application (items 1 and 2);

2. R/D&I institutions (3 and 4);

3. <u>functions</u> (3 and 4);

4. <u>knowledge base</u> (5 and 6); and

5. <u>personnel</u> (7).

Further, a review of Matrix 2 reveals the implicit model diagrammed in Figure below.

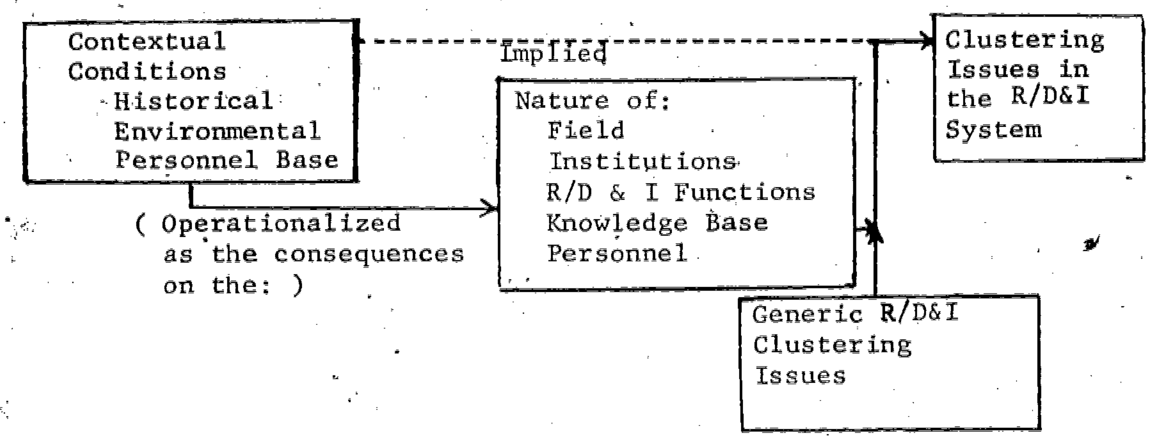

Figure 11

<u>Impact of Contextual Conditions on R/D&I System Clustering</u>

The dependent variable (the clustering of R/D&I functions into institutions) is relatively simple in this case. We are concerned with how the generic R/D&I functions are translated into sets of activities being performed in the various real institutions of a concrete R/D&I system. Some of the specific sub-issues would be:

1. How much specialization do we find within R/D&I functions?

2. To what extent do we find several R/D&I functions clustered together in single institutions or institutional arrangements (cooperation)?

3. In what function location in the R/D&I system (at knowledge generation, production, knowledge utilization, etc.) do we observe any such clustering?

4. Do the clusters tend to occur by the joining of contiguous or adjacent R/D&I functions or of looped (non adjacent) R/D&I functions? Are the clusters linked in serial or parallel networks?

5. Do we observe gaps in that nowhere does a given R/D&I function seem to be fully carried out?

6. Is the observed clustering stable or temporary?

7. How formal and visible is the observed clustering?

8. To what extent is it legally and socially sanctioned?

5. Selecting a Set of Clustering Dimensions and Contextual Conditions for Detailed Analysis

Matrix 3 takes our analysis a step further by relating the above dimensions of clustering to the previously discussed contextual conditions. However, while Matrix 3 in its entirety is a framework that would be proper for a full analysis of a specific case, it is still too large and requires too specific a level of knowledge to be useful for a general illustrative analysis. Specific events, regulations, etc. would be of great importance in a given case but cannot be generalized for useful presentation. It becomes necessary for us to further simplify Matrix 3.

Contextual Condition	Specialization	Extent	Location	Contiguity vs. Looping	Series vs. Parallel	Gaps	Stability	Formality	Sanction
	Dimensions of Clustering								
Institutionalization									
Legal/Political/Social Regulation									
Political/Social/Economic Support									
Technology Required									
Knowledge Base									
Maturation of Specialties									
Professionalism of Personnel Base									

Matrix 3. Contextual Analysis of Clustering of R/D&I Functions

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We can do this by first selecting a subset of dimensions of clustering which we will examine. These are:

1. specialization levels;

2. the extent to which clustering of R/D&I functions takes place;

3. whether the clusters are of contiguous or looped R/D&I functions (i.e., level of contiguousness);

4. the degree to which gaps (in R/D&I functions) are to be found in R/D&I systems.

Secondly, we can also elect to examine a set of contextual conditions that captures several critical dimensions but not all the richness. Thus we can look at time effects in terms of the impact on both the system and the maturation of specific specialties. Therefore, we shall use the idea of the institutionalization of the field to denote such effects on both the system and individual specialties. Support and regulation are often interrelated and have an enormous variety of possible aspects in terms of who, how, when, why, etc. For illustrative purposes we will limit ourselves to a simpler issue, namely: Does support and/or regulation in the system come from the producers or users of knowledge and products? Stated in this way, the issue also allows incorporation of an important aspect of the professionalism condition; i.e., whether the dominant professionals in the system are to be found in the producer or user functions or both (i.e., where they exert controls). Technology will be considered only in terms of the effects of economies of scale. The knowledge base will be considered only in terms of its level of certainty (including notions of science vs. craft).

The intersection of the selected subsets of clustering dimensions and contextual conditions are reflected in the shaded columns in Matrix 3. This is not to imply that the other clustering dimensions and contextual conditions are not important, but rather that those selected do permit a useful first level of illustrative analysis and insight, and capture well the two original aspects of specialization and configuration.

6. Developing a Detailed Analysis of the Clustering Issue

We can now reformulate Matrix 3 into its simplified form as in Matrix 4. The "x's" in the cells represent hypothesized relationships between the expected type of clustering and the selected contextual conditions. Those cells for which no relationships have been indicated cannot be predicted by the individual contextual variables alone. The limitations of two variable propositions is also recognized. It is our assumption that such analyses are but a first step in an enrichment process permitting the construction of more elaborate theories and models at each step of the analysis, as is found necessary and useful.

SELECTED CONTEXTUAL CONDITIONS		SELECTED DIMENSIONS OF CLUSTERING							
		Level of Specialization		Extent of Clustering		Contiguity of Functions		Gaps in System	
		High	Low	High	Low	High	Low	High	Low
Institutionalization of Field	High	X							X
	Low		X					X	
Regulation and Support Dominated	Producer				X	X			
	User			X			X		
Technology-Economy of scale	High	X		X					
	Low		X		X				
Knowledge Base Certainty (Sci/Craft)	High	X			X	X			X
	Low		X	X			X	X	

Matrix 4. Selected Dimensions of Clustering as Determined by Selected Contextual Conditions

Matrix 4 can also be presented in the form of the model as shown in Figure 11. A complete discussion of this model and the admittedly debatable relationships indicated would be beyond the scope of this study; and, in the final analysis, validation and modification will have to await empirical testing. It is a poignent commentary that the literature has not to date focused attention on the complex of variables in Matrix 4 and Figure 12.

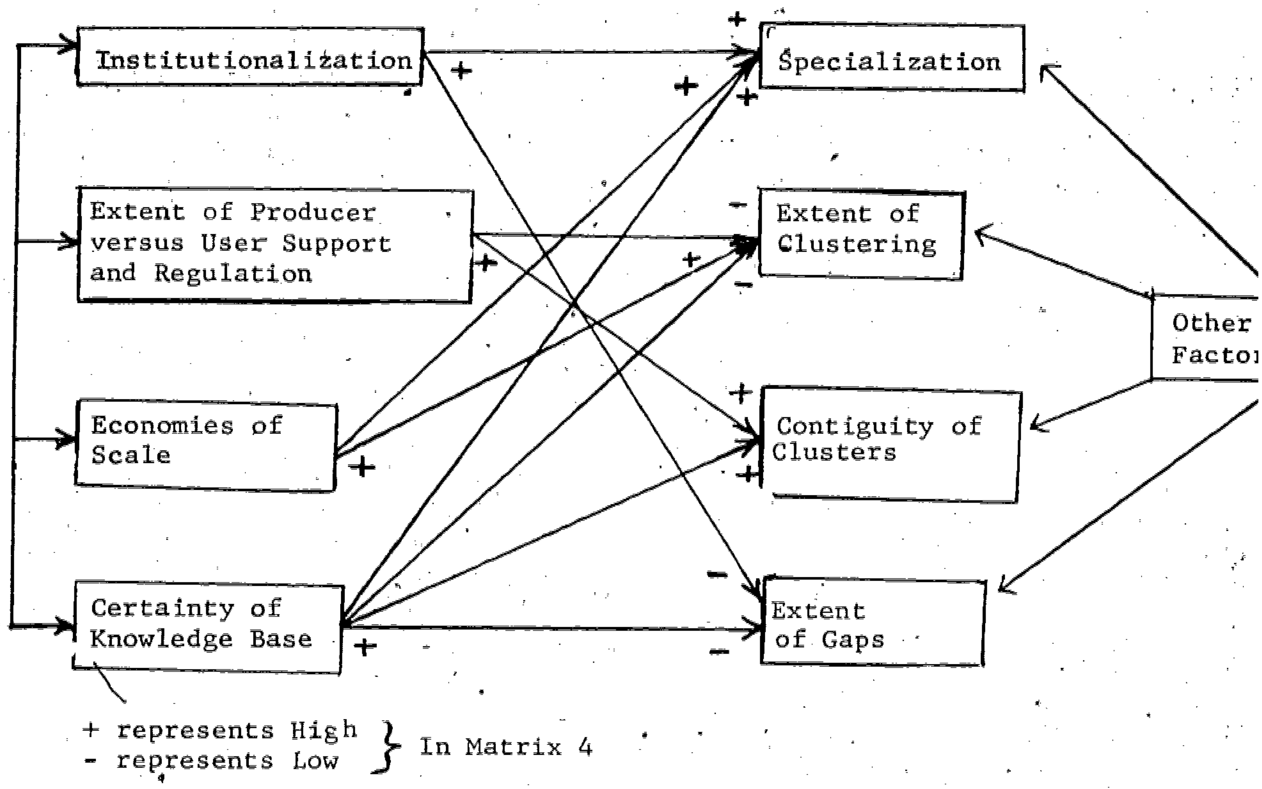


Figure 12.

Contextual Determinants of Clustering Model

For now we can argue that as institutionalization progresses, there will be a tendency for specialization to grow as tasks become learned and as programmed procedures and associated facilities are developed, thereby facilitating the division of activities. Further, as specialties mature over time there is a tendency for sub-specialties to crystalize, even eventually leading to new specialties and disciplines. Increasing economies of scale make specialization more efficient. Increased certainty of knowledge facilitates and stimulates specialization by permitting codification and easier stage-to-stage transfer.

As user power (in the forms of support and regulation) grows in the system, we might expect to find users exercising control over more R/D&I functions in the system - - resulting in larger clusters of such functions. Economies of scale tend to generate the larger institutions that can exploit these opportunities, and they, in turn, are able to absorb associated R/D&I functions, thereby reducing technology transfer costs and supporting the large scale operations. On the other hand a more certain knowledge base makes it less vital that interdependent R/D&I functions operate out of the same institution.

The previously mentioned issue of increasing user power would tend to generate looping rather than contiguous clusters as users reached into the need identification and idea generation stages. A more certain knowledge base would facilitate interstage technology transfer, but the concurrent specialization would tend to stimulate a step-by-step linkage process. Similarly, interstage gaps would tend to become filled, especially as the field became more institutionalized.

The model in Figure 12 indicates another important aspect, namely the interdependence between the contextual conditions. Thus the type of regulation will tend to be related to the level of institutionalization as well as the extent to which economies of scale become exploited. In turn the rate of institutionalization will be partially determined by the problems generated by the uncertainty of the knowledge base; and so on.

The above discussion can also be presented in the form of a series of propositions

Proposition 1. The more institutionalized a field is (i.e., the more formalized, stable and mature are its institutions and specialties), the greater the specialization of activities and the fewer the functional gaps in the system.

Proposition 2. The more that regulation and support (legal, social, political and economic) is determined by the users (as opposed to producers), the greater the extent to which R/D&I functions are clustered into specific institutions and the more likely are we to find such clusters taking the form of non-linear loops.

Proposition 3. The more the technology creates economy of scale opportunities and requirements, the higher the level of specialization and the more clustered are the various R/D&I functions in specific institutions.

Proposition 4. The less certain (i.e., craft-like) the knowledge base:

a) the lower the level of specialization;

b) the greater the number of functions to be found clustered into institutions;

c) the less likely it is that these functions represent adjacent stages in the R/D&I systems model; and

d) the more likely it is that there will be functional gaps.

The model in Figure 12 also points to another consideration; namely, the indication that the four selected contextual conditions, while potentially very important, are not the only determinants of the clustering dimensions. Thus, the level of institutionalization of the system and the level of certainty of the knowledge base contribute to but are surely not the exclusive determinants of the appearance of gaps. In this case we are dealing with a variable that can be changed by deliberate and direct policy and management action. We can act to fill the gaps that tend to emerge in the given conditions.

A further review of the relationships in these propositions and the model in Figure 12 indicates four additional considerations.

1. The relationships are uni-directional. The level of certainty of the knowledge indeed helps to determine the extent of gaps in the R/D&I system, but a change made by filling these gaps will not, at least directly, have any impact on the nature of the knowledge base.

2. The contextual conditions (which are the independent variables) are essentially non-manipulable, at least in the short run. The economics of scale are there or they are not.

3. These independent variables can vary over a wide range (e.g.: from very high to very low levels of institutionalization) and at this point, we have no measures of their parameters or relative weights in the relationships.

4. There are also a great number of combinations that are possible between the variables, and (as we noted earlier) there may be other determinants of the dependent clustering conditions. It is therefore not possible to take a given clustering configuration and identify a unique contextual condition that produced it.

With these four factors in mind, we recognize that the utility of the model must come from its explanatory rather than its manipulatory power. If we can better understand why a given R/D&I system has the clustering (or more broadly, configuration) that it does, then we can avoid attempts to build or retain inappropriate system structures. Furthermore, we can determine policy options and managerial strategies that are properly adapted to the fundamental constraints of the context, rather than working at cross purposes with its natural characteristics.

We could pursue two different analysis strategies from this point. One would be to search, both deductively and inductively, for other determinants of the clustering dimensions. This would undoubtedly be productive and fascinating, and could lead to a rich theoretical understanding of the issue with important potential policy implications. It would however depart from the scope of this limited illustrative analysis.

A second and more limited strategy is to follow the partial implications of various configurations of contextual determinants into the emergent clustering and then on to the managerial and policy strategies that would seem to be congruent with that emergent configuration, given these antecedent contextual conditions. We will pursue this latter approach.

7. Scenario Case Analyses of Emergent Clustering Resulting from Different Contextual Determinants

As a first step let us examine a number of hypothetical yet realistic case alternatives in which we will establish contextual profiles and "derive" the emergent clustering. Since it is our objective here to be illustrative rather than to make a more formal cross sectoral comparative analysis we will limit ourselves to a relatively casual level of linkage into actual real world situations. Thus, we will for now need to do a minimum level of such linking to illustrate our points. We must also reiterate the points noted above: we do not know the appropriate weighting of effects across the contextual features nor do we imply that these are the only variables influencing the emergent cluster. Thus the following analysis should be understood as an examination of partial effects that would tend (although we would expect significantly) to influence the observed clustering in approximately the "derived" direction. We will then go on to discuss the implications in each case for management strategies. These cases are shown in Figure 12.

A simple analysis method has been used. A simple rating system (from very high to very low and using equal intervals) was set up for each contextual condition and the relative weighting across variables was assumed to be equal. This latter assumption appears as reasonable as any other at this time and would need to await empirical investigation to be modified. A series of hypothetical case examples (A through F) were set up and the net scores for each of the clustering dimensions was calculated (using the relationships indicated in the model in Figure 12 and simple arithmetic computation). These net scores were converted back to a very high to very low scale according to the table shown (which allows for the fact that some of the clustering dimensions are influenced by two and some by three contextual variables). The resultant (or hypothesized) dimensions of clustering are indicated in each case in Figure 13.

Contextual Conditions	Cases					
VHi Hi Med Lo VLo						
+2 +1 0 -1 -2	A	B	C	D	E	F
Institutionalization	VLo -2	VHi +2	VHi +2	VHi +2	Lo -1	Med 0
Producer (vs. User) Regulation	VLo -2	VHi +2	Med 0	Med 0	Med 0	Lo -1
Economics of Scale	VLo -2	VHi +2	VHi +2	Med 0	VLo -2	VHi +2
Certainty of Knowledge Base	VLo -2	VHi +2	Hi +1	Hi +1	VLo -2	Hi +1
Derived (hypothesized) Dimensions of Clustering*						
Specialization	VLo -6	VHi +6	VHi +5	Hi +3	VLo -5	Hi +3
Extent of Clustering	Hi +2	Lo -2	Med +1	Med -1	Med 0	Hi +2
Contiguity of Clusters	VLo -4	VHi +4	Hi +1	Hi +1	Lo -2	Med 0
Extent of Gaps	VHi +4	VLo -4	VLo -3	VLo -3	VHi +3	Med -1

*Due to the possible range of ratings and the varying number of independent variables the ranges across clustering dimensions will vary. The following conversion table has been used.

For Dimensions	VHi	Hi	Med	Lo	VLo
Specialization & Extent of Clustering	+6 to +5	+4 to +2	+1 to -1	-2 to -4	-5 to -6
Contiguity of Clustering & Extent of Gaps	+4 to +3	+2 to +1	0	-1 to -2	-3 to -4

Figure 13

Comparative Hypothetical Cases of Clustering Characteristics as a Consequence of Varying Contextual Conditions

We must recall our previous cautions. The indicated clustering dimensions can only be considered indicative and illustrative but can, we we will now demonstrate, provide some provocative insights.

i. Case A

Cases A and B represent the two extremes. In Case A we see what we could term a highly underdeveloped R/D&I context. The system has not proceeded far in becoming institutionalized. The knowledge producers lack any control and regulation over the system, no economics of scale have developed in a craft-like field (i.e., a field with a highly uncertain knowledge base). While undoubtedly exaggerating in some aspects (particularly as regards the extremes of low institutionalization and user control) one cannot but help thinking that the educational R/D&I system until very recently almost fit this description. (Though as we will note, Case E perhaps more closely reflects the educational R/D&I system). The criminology aspects of the law enforcement R/D&I system also might almost be included in this category.

If we move down Figure 13 to examine the implications for the R/D&I system clustering for Case A we would be hypothesizing a very low level of special-ization but a very high degree of clustering together of R/D&I functions into a consequently small number of institutions. However, these institu-tions would not be involved in sets of ajacent roles from basic research through development through production to implementation, etc. -- but would rather tend to unite combinations of (for example) development and utilization (or even basic research and utilization); or development, marketing and evaluation research; and so on -- and importantly, would be leaving many R/D&I functional areas virtually undealt with (i.e., there would be many gaps). Such an R/D&I system structure would indeed seem to be congruent with the "underdeveloped" description we gave to the con-textual environment, and, again in many (though not all) ways reminds us of some parts of the education and law enforcement sectors mentioned above. At least then, in terms of a relatively casual empirical basis, there would appear to be some face validity to our schema as far as this has emerged from the Case A discussion.

ii. Case B

Case B, by contrast, represents a highly institutionalized system controlled by the knowledge producers. Economics of scale and certainty of knowledge base are high. These conditions remind us of those to be found in the industrialized high technology hardware sectors (e.g.: automotive, aircraft, etc.). Also characteristic of the types of industries mentioned above are the hypothesized clustering characteristics of high levels of specialization in a relatively large number of institutions following highly linear progressions of functions and leaving few or no gaps.

iii. Case C

Case C varies from Case B only in that there is a relative balance between users and producers in their level of control over the R/D&I system as compared to the very clear producer control of the previous situation, and a somewhat reduced level of certainty in the knowledge base. The consequences for the emergent clustering are found in a diminished linearity and a somewhat reduced number of institutions. With the very high level of institutionalization, the high economics of scale, and a seeming balance between the powers of producers and users, this case might remind us of the more industrialized segments of the health sector (e.g.: the drug industry). The high but not total level of certainty of the knowledge base may also fit. The hypothesized high specialization and the low gaps left by the medium sized and modestly looped institutions again fits the drug industry.

iv. Case D

Case D varies from Case C only in taking the economics of scale to a lower level with the effects of generating somewhat smaller clusters and institutions with a little less specialization. The difference might be explainable by reduced markets or less developed production technologies (e.g.: even the same drug industries in less developed edonomics; or perhaps the agricultural industry).

v. Case E

The context for Case E possibly reflects that of the educational sector better than our speculation for Case A. Economics of scale and certainty of knowledge base are still very low, but we observe a less powerful user group though a somewhat higher (though still underdeveloped) level of institutionalization of the R/D&I system in its sector. The hypothesized clusters are still looped rather than contiguous but in not quite as extreme a manner as in Case A and the sizes of the institutions are somewhat smaller. Again these characteristics seem to represent an even better description of the actual situation in education, and the terminology example given above.

vi. Case F

Case D was described as a form of Case C, but operating in a possibly less developed environment. Case F could also be seen as a less developed form of Case C, but this time in terms of a lower level of institutionalization and reduced level of producer power in the system. One could readily see how a Case F context could mature over time into a Case C profile. We could therefore be talking about either an earlier stage of development or a less developed segment of a sector. Thus we might associate Case F with the medical procedures or the preventive medicine R/D&I programs of the health field. The hypothesized level of specialization is lower, the extent of clustering greater, gaps are more common and the configurations far less clear and linear -- all characteristic signs of a less developed condition. The differences as opposed to the previous drug segment of the health field, at least in a preliminary way, do seem to concur with observation.

So far, then, we have been able to demonstrate that the selected contextual conditions do seem capable of providing a realistic and rich description of varying real world situations and, more importantly, that the hypothesized clusteral configurations do not depart dramatically from those that seem to be observable in the same real world situations. Further, the more realistic we make the contextual descriptions, the more realistic seem to become the descriptions of the configurations. Finally we have seen that the model realistically reflects that as dynamic developmental changes in context occur over time, these changes are reflected in emergent structures. Even while remembering our previous cautions, these are encouraging findings. If we can hope to develop such a level of insight from comparative contextual analysis, we may hope to continue productively to the next step of exploring some managerial and policy implications for R/D&I sustems.

8. Initial Analysis of the Implications of Contextual Determinants of Emergent Clustering for Management/Policy Strategies.

A number of management issues can be identified which relate to these various R/D&I system configuration patterns. For example, a key generic R/D&I issue is that of determining appropriate start and stop points for programs in the work flow sequence. Frequently, research personnel are loath to let go of the project "children" to whom they have given birth. Sometimes they can be observed holding on to programs well into production and even marketing stages, long after they should have either passed the project on to others for development, etc., or abandoned it. Issues of judgment, appropriateness of skills and efficient use of talents are involved. While this is always a problem, it would be likely to appear in different forms in the various above cited cases. In Cases B, C, D and to a degree F such behavior is likely to be more visible and clearly more incongruous to the role of researcher than in the Cases A and E, where role definition is far less clear. Thus, in Cases B, C, D and F, it may be more easily recognized and managed. In turn such behavior may even be seen as a virtue in the Case A and E contexts (although the previously mentioned issues are likely to remain). We will return to this question again. A related question is the classic Not-Invented-Here syndrome which is likely to appear in more aggravated forms where R/D&I functions are highly specialized and differentiated (as in the Cases B and C).

Another example of a pertinent management question could be in the differential utility and applicability of various management techniques such as PERT. The high degree of task, function and role definition to be found in the Case B and C contexts make the application of such a method very rational. Tasks can be specified and deliniated; resource and time requirements can be estimated to a reasonably acceptable level of accuracy and reliability. Such may be far from the case for Cases A and E. As a consequence, attempts to transfer this technology (which was developed in the more definitive aerospace/military/industry contexts) to the world of education (for example) without appropriate review and redesign for the changed context was bound (as it did) to lead to misapplication and disappointment.

The use of Delphi techniques to obtain estimates of complex and uncertain phenomena (frequently of an environmental nature; e.g.: for forecasting purposes) within institutions is another good example. The problem is to find a series of R/D&I "experts" who can see beyond their immediate task and time environments. (1) In cases such as B and C, this may not be so easy, because R/D&I personnel are all too often limited in their perspective by the very specialization that makes them productive. In contrast, in cases like A and E there is a much greater tendency for personnel to be generalists - - in fact, the normal decision processes are essentially Delphic, thereby making the use of such an approach (while relatively easy) almost pointless.

The management of functional interfaces is another area of comparative interest. In highly specialized and differentiated institutions, there are many interfaces to cross between groups with relatively well defined and impermeable boundaries. Coordination becomes a major issue, often calling for liason mechanisms, etc. This would seem to be likely to occur in cases such as B and C. In contrast, Cases A and E would have far fewer interfaces to cross, many functional overlaps, and generally fuzzy boundaries between activities. Potentially offsetting these helpful effects would be the factors of lack of linearity, which might make interface differences (of perspective and discipline) larger to overcome - - with the existence of functional gaps, creating transfer problems between certain R/D&I functions. As we saw earlier, such shortcomings usually accompany the very same cases that have the lower number of interfaces to deal with, as in Cases A and E. In summary, we would tend to find differing types of interface problems across varying R/D&I contexts, but not necessarily any overall greater or lesser problems; and this indeed seems to be the general experience.

9. Detailed Analysis of the Implications of Contextual Determinants of Emergent Clustering for Three Selected Areas of Management Concern

Similar discussions could be presented to cover a wide spectrum of R/D&I management issues and techniques, but this would be beyond our present illustrative purpose. Rather, we now select the above noted management issues and methods which we will examine somewhat more formally in terms of our present concerns with the importance of the context/clustering nexus. These were selected because they appear to cover a broad spectrum of areas of management concern. The selected areas are:

1. Methods of Program Control (including such techniques as PERT as discussed above). This area deals with the control of work and activity flow within an R/D&I institution.

2. Interface Management, which is concerned with the linkages within institutions.

3. The use of Delphi type techniques in relation to issues of an institution's relationship with its environment (in terms of goals and forecasts).

These three topics provide us with a wide ranging sample of managerial issues of both an internal and external R/D&I system nature.

Matrix 5 is an attempt to relate the ease or difficulty in using or dealing with the above three R/D&I management approaches and issues to the four dimensions of clustering previously discussed. The over-simplification is

Matrix 5. Use Characteristics of Selected Management Approaches in Varying Clustering Conditions

Use of Selected Management Approaches	Dimensions of Clustering							
	Specialization		Clustering		Contiguity		Gaps	
	High	Low	High	Low	High	Low	High	Low
1. Program Control								
Difficult		x		x		x	x	
Easy	x		x		x			x
2. Interface Management								
Difficult	x			x		x	x	
Easy		x	x		x			x
3. Use of Delphi								
Difficult	x			x	x		x	
Easy		x	x			x		x

again recognized and calls for both enrichment and validation by empirical research. This should be carried out, but the indicated relationships have a face validity.

For example, Program Control is rated as being difficult under conditions of low specialization and vice versa. As was earlier implied, the lack of certainty attached to stage-by-stage tasks in an R/D&I process makes it difficult to define the task requirements, etc., and hence to use methods such as PERT. The more R/D&I functions that can be found clustered together within a single institution, however, the easier it becomes to develop and maintain a program plan, since one is dependent on fewer difficult to control and forecast external agents (often a major problem in PERT systems). The more linear the relationships between R/D&I functions (high contiguity), the easier to plan and predict the progress of the step-by-step progression. Finally, the increasing incidence of system gaps progressively adds uncertainty to the process, making the use of programmed methods of control more difficult.

We have already discussed most of the relationships concerning Interface Management. As regards the extent of clustering, we could expect that interface problems would be relately easier within rather than between institutions, and hence favorable for the case of higher clustering levels. Also Delphi methods would, as we noted, be easier in low specialization organizations, and we would expect similar experience in larger, looped (non-contiguous) institutions with few gaps (i.e., those institutions having broader, more interdisciplinary and complete perspectives among personnel).

Using the above relationships we can now examine the varying implications for the six previously discussed cases (A through F). Referring back to Figure 13 and Matrix 5, and once again using a simple computational approach, we can combine the various ratings of the clustering dimensions (in Figure 13) with the suggested implications for the management issues in Matrix 5 (using the same scoring procedure: V Hi + 2 to V Lo - 2). Thus in Figure 13, Case A was shown as V. Lo on specialization, which would lead via Matrix 5 to a "very difficult" (VDi) rating on Program Control with a -2 score. Similarly the High extent of clustering for Case A generates an "easy" (E) implication with a score of +1, and so on. The net scores are then reconverted for each management issue for each case.

This reconversion is shown in Figure 14. We have also computed the overall scores and ratings as an attempt to estimate the extent of the "management problem" for each case.

From Figure 14 we observe that Program Control was rated as easy for Cases B, C, and D (essentially the high specialization, low gap cases) and difficult in Cases A and E (the converse cases). That is, the highly developed R/D&I systems (which as we suggested could be descriptive of the automotive, aircraft and drug industries) were ideal environments for such methods s PERT. We had described Case D as somewhat less developed, and although .he differences were small, the slight change would indicate a possible degree

Use of Selected Management Approaches	Cases A	B	C	D	E	F
1. Program Control	-5 Di	+5 E	+5 E	+4 E	-5 Di	0 Med
2. Interface Management	-1 Med	+1 Med	+1 Med	+2 Med	-1 Med	0 Med
3. Delphi Methods	+3 E	-3 Di	-1 Med	+2 Med	+1 Med	0 Med
4. Overall Management Problem	-3 Med	+3 Med	+5 Med	+8 E	-5 Med	0 Med

Items	VE	E	Med	Di	VDi
1-3*	+8 to +6	+5 to +3	+2 to -2	-3 to -5	-6 to -8
4**	+24 to +16	+15 to +6	+5 to -5	-6 to -15	-16 to -24

E = Easy

Di = Difficult

* (Product of 4 variables)

** (Product of 4 variables by 3 cases)

Figure 14

The Use of Selected Management Approaches in Six Comparative Cases of greater difficulty. The less developed R/D&I systems in Cases A and E (education or law enforcement perhaps) are seen as being much less suitable environments for such approaches, with the intermediate Case F (e.g.: preventive medicine programs) being a quite unsuitable environment. In general, this seems to concur with experience.

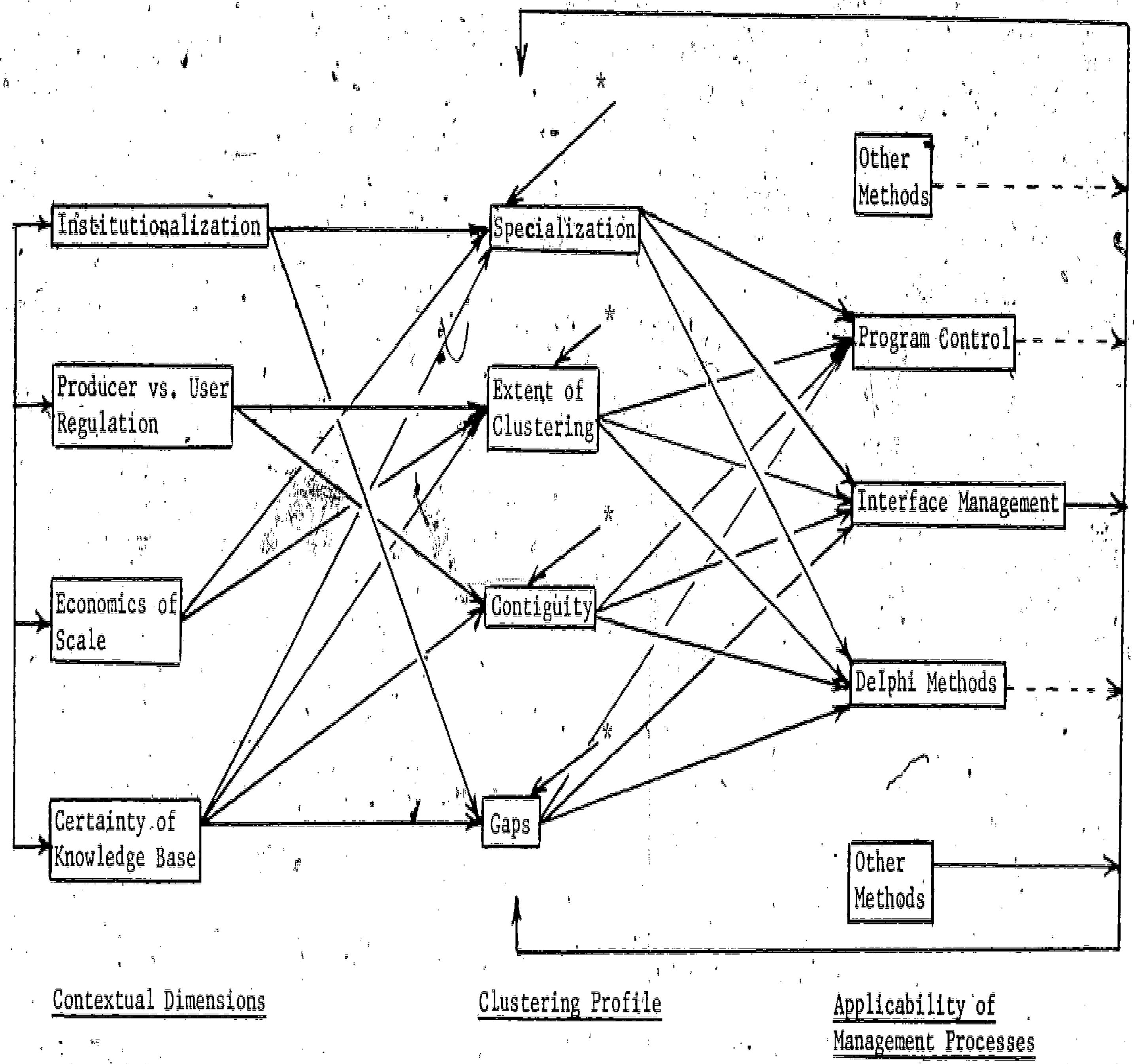
When we turn to Interface Management, no such differences appear. As we suggested earlier the offsetting factors in each situation generate a net balance in each case (although this may be an artifact of our equal weighting procedure -- this would require empirical study). While we are not confident of the meaning of a medium rating across the board, the relative similarity across the cases is as we tend to observe it. Experience tells us that interface management is a problem everywhere; and it has not been our experience that it is an especially greater problem in any particular context as compared to others. Thus, instead of being concerned with differences in the weight of the problems across cases, we would be more concerned with differences in the specific issues and the points where the issues occur as these relate to differences in contexts.

The use of Delphi reflects neither of the first two patterns. Cases A and B (the extreme cases) show the greatest difference (as expected), but Case C with its larger and less linear clusters provides a better environment than Case B (a difference not to be observed for Program Control). Case D is a better environment yet, reflecting the lower specialization. The difference between Cases A and E appears to mirror the shifts between Cases B and C. Apart from the shift between Cases A and B, the overall impression is that the Delphi approach is usable in most environments, to a degree, but does better as the contexts become "fuzzier" (as many proponents of the methods have contended -- as for example in recommending its application to government policy making). (1)

The ratings for the overall management problem are especially interesting in their uniformity, with a single possible exception, Case D (although even there the difference is not dramatic). The common language and practically stated interpretation of this result could be: "While the specific management problems across the various situations may be different from each other, in total they do not add up to a substantially greater or lesser problem." Whether such an hypothesis could stand up under empirical study is still an open question, but the suggestion is provocative and one that we have not seen spelled out in this (or any other such) manner before.

Finally, we must link back to the contextual conditions that generated the case clustering conditions. The clustering profiles that we used to analyze the management approaches issue were derived as a product of the contextual conditions profiled in the top half of Figure 13. Thus, in fact it is to those contextual profiles that we are connecting the above management implications. That is, we could say that in contexts such as Case A (i.e., with low levels of institutionalization, high user/low producer regulation, few economics of scale and an uncertain knowledge base), formal Program Control methods such as PERT will work only with difficulty, Delphi methods with relative ease, and interface management will present no unusual problems (beyond the norms).

This process of linking of contextual conditions with management implications could be repeated for the other cases. In the model in Figure 15 we show how the contextual conditions link into the applicable management processes through the profile of the clustering of R/D&I functions in the instituions in the R/D&I system. The model also indicates one more point that was made earlier, and with which it is appropriate to conclude this discussion. This is that unlike the contextual conditions which acted as relatively unchangeable parameters, the management processes used could have a significant impact on the clustering (configuration) of the R/D&I system, creating the earlier discussed dynamics. Obviously this does not apply equally to all management actions, and in the cases reviewed it would be Interface Management that might be expected to have the major impact. The point to be made is that management actions can influence the situation, but these must be selected so as to be appropriate to the context in which they will be used.



* Other factors

** Management Actions

Figure 15

Model Relating Comparative Contextual Dimensions, Clustering Profile and Applicability of Management Processes

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CHAPTER SEVEN

ENTREPRENEURSHIP:

AN ISSUE OF THE HISTORICAL DEVELOPMENT FEATURE

ERIC

ENTREPRENEURSHIP:
AN ISSUE OF THE HISTORICAL DEVELOPMENT FEATURE

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FIGURES

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CHAPTER SEVEN

ENTREPRENEURSHIP:

AN ISSUE OF THE HISTORICAL DEVELOPMENT FEATURE

INTRODUCTION

In the preceding chapter, we illustrated the use of the contextual analytical framework in relation to the contextual feature: institutional base. In this chapter, we will similarly illustrate the use of contextual analytical framework in relation to a specific issue of the historical development feature: the role of the entrepreneur in the historical development of R/D&I systems.

This issue was selected through a process of progressively narrowing down from the historical development feature. That discussion is contained in the full report. Essentially, this involved the identification of a factor that has been observed to be of critical importance in the dissemination, transfer and implementation of innovations, especially in less than fully matured R/D&I systems. Thus in the earlier phases of the life cycle of R/D&I systems the need for "product champions" or "entrepreneurs" has been shown to be of vital importance in the "success" of new product and process innovation introductions and adoptions.[2, 3, 8]

The issue of entrepreneurship is presented as one illustration of the several such issues analysed in the full report. Our purpose is to demonstrate the process by which such a question can be examined from the generic perspective, leading into a potential comparative analysis across several contexts. In this analysis the contexts will be hypothetical, but the extension to real world conditions should be relatively self evident.

The analysis will follow a "reductionist" methodology. On a step-by-step basis, we will gradually narrow the focus of the analysis of the "entrepreneurship" issue until we have reached a level of analysis which is limited enough for an analysis to be manageable yet still rich enough for meaningful illustrative policy analysis. In the process of narrowing the focus of analysis, we shall "carry along" significant aspects of a fuller contextual analysis to enrich a more specific illustrative policy analysis. Additionally, we shall have created a "footpath" whereby a more specific illustrative policy analysis may be "led back" into an interaction with the fuller contextual analysis.

To further enrich the specific illustrative policy analysis, we will provide a comparative analysis across three sectors from empirical case studies.

To begin our narrowing of the focus of analysis, we will limit our analysis to the following:

1. the producer (or developer/producer) as entrepreneur (recognizing that entrepreneurs may also be users, disseminators, etc., but omitting these from this analysis);

2. the early phases of historical development of R/D&I system (through a very limited comparison will be made with a more mature stage of the innovation process).

I. THE PROCESS OF CONTEXTUAL FEATURE ISSUE ANALYSIS: NARROWING THE FOCUS

1. A "Full" Contextual Feature Issue Analysis

We have defined "context" as the interactive effect of the whole set of R/D&I system features. To permit full analysis of the feature issue of "entrepreneurship" in R/D&I systems as a function of context variation, it would be necessary to interact this feature issue with each of the R/D&I system features and feature issues. That is to say, we would initially explore the set of research and policy questions that emerge from the interaction of entrepreneurship as an issue with, for example: historical development (the role entrepreneurship plays in the institutionalization process; how it functions in the various developmental phases; what happens to entrepreneurs over time; etc.); environment (what are some of the legal/political constraints that may operate on the entrepreneur); comparing the development, production and marketing/dissemination sub-systems (how might the type of skills required differ across the various functions of an R/D&I system). Thus a complete analysis across every feature of an R/D&I system context would be necessary to establish a basis for the full contextual analysis. This is illustrated in outline form in Matrix 6.

Matrix 6 provides an illustration, in outline form, of how such a full contextual analysis could be done. In this first instance, Matrix 6 is a first cut at the process and relies on the knowledge and experience of the analysts -- with the recognition that the analysis is likely to be improved through a series of iterations, as more is learned. There are clearly, therefore, advantages to the use of interdisciplinary and intersectoral teams in the process. From a pragmatic perspective, it is vital to avoid becoming bogged down at this point by concerns with exhaustiveness or the desire to include everyone's favorite perspective.

. Delineation of Key Issues and Characteristics

A. Extracting Key Issues from the Full Contextual Analysis

A complete and systematic analysis of each cell of Matrix 6 that would be grounded in the literature is beyond the scope of this review. Furthermore, such an exhaustive approach would not be practical for policy making. In order to focus in on questions of both high priority and of general applicability to the area of particular concern (in this case entrepreneurship in R/D&I systems), it is necessary to narrow down the range of issues to be analyzed.

MATRIX 6:

ILLUSTRATIVE FULL CONTEXTUAL ANALYSIS OF ENTREPRENEURSHIP ISSUE

FEATURE	ENTREPRENEURSHIP
1. Environment	Legal/political constraints Impact of norms and values Economic constraints Funding priorities Technological requirements Knowledge base
2. Historical Development	Role in institutionalization Which phase needed Establishment of institutions Impact on acceptance
3. Institutional Base (Network of Institutions)	Entrepreneur as linking agent Effect of boundaries -- skills required Effect of structure, configuration, size, varying entrepreneur role legitimacy Level of sponsor support
4. Goals/Policies/Strategies	Effect of goal setting Time horizon of goals Perception of goals
5. Administrative Processes	Control of Mobilizing support and resources
6. Personnel Base	Recruitment and selection Career patterns Professionalism Obsolescence Training and development Distribution of expertise Status Motivation and satisfaction

FEATURE	ENTREPRENEURSHIP
7. Funding	Constraints on use Level (support for)
8. Information Flow	Role Information seeking skills
9. Innovations	Life Cycle Impacts and benefits - role Effect of character of the innovation (or product)
10. Need Identification	Role Skills required Responsiveness to user demands Institutional base Position Personal characteristics
11. Generation/Research	Role Search skills Tech transfer role Information flow role
12. Development	Role Skills

FEATURE	ENTREPRENEURSHIP
13. Production	Role Skills
14. Marketing/Distribution/ Dissemination/Diffusion	Role Skills
15. Acquisition	Role of key personnel Product champions Skills of user personnel
16. Implementation/ Utilization	Role of key personnel in implementation Producer/user relationship Producer characteristics Implementation capability User characteristics Innovation entry points Barriers (overcoming) In-house capability Role of entrepreneurs in utilization User relationships with sources of innovation User characteristics influencing acceptance of innovation
17. Support Services	
18. Evaluation Research	
19. Research R/D&I	

This is done by extracting those key issues which surface from the overview of Matrix 6, in the sense of being either critical or pervasive across many dimensions of the R/D&I system context. As a first step towards the definition of key policy issues, it would seem reasonable to concentrate our further effort on these issues. In this case we can identify the following:

1. the role of the entrepreneur as this shifts across the various functions of the R/D&I system (development, marketing, etc.);
2. the skills and characteristics of entrepreneurs;
3. the entrepreneur as a link between the knowledge producers and users (with special reference to the problems of need identification, implementation and utilization).

We must reiterate that these are certainly not the only issues that might be of concern to the researcher, manager or policy maker. Others can and (as necessary) would be selected. These are, however, issues that from our analysis of Matrix 6 appear to be of general and sustained importance across R/D&I systems, and hence worthy of some priority for a first (and illustrative) analysis.

B. Selection of Key Entrepreneur Characteristics

To provide a sharper focus for analysis of these key issues, it will now be useful to describe a set of entrepreneur characteristics for more detailed consideration. We select (from Matrix 6 in a su[illegible] ized form) those five entrepreneur characteristics which it would appear have a critical impact on the key issues as we have identified them:

<u>Orientation</u> - Is the focus of the entrepreneurship local or cosmopolitan?

<u>Perspective</u> - Is the emphasis a theoretical or applied; innovation or on utilization?

<u>Legitimacy of origins</u> - What is the impact on legitimacy if the source of entrepreneurship is external to the user organization; whether the source is peripheral or core?

Institutional Role location in system - Where is the primary entrepreneurial activity to be found: in the core or at the periphery of the producer organization.

Skills - What type of skills are required in performing entrepreneurial functions: need identification, marketing, consulting/service, development:

C. Interactive Analysis of Key Entrepreneur Characteristics

Further, it will now be helpful to examine the interaction between the entrepreneur characteristics to determine their independence, robustness and general causal direction -- as is illustrated by Matrix 7.

The implications of the Matrix 7 are that:

1. There is a mutual interaction between orientations and perspectives. In fact, these would seem likely to be highly inter-correlated concepts which are (for our policy purposes) of only marginal difference. Thus we can elect to collapse these into a single compound variable: "orientations/perspectives".

2. Skills (which were defined in terms of need identification, search, R&D (developmental), marketing and consulting service skills) seem similarly to be likely highly correlated with orientations and perspectives; but on both theoretical and practical grounds (manipulability), it seems desirable to maintain this variable separately in the analysis. This possibility of manipulability of the skills variable (through recruitment and training) may be particularly significant.

MATRIX 7:

THE INTERACTION OF KEY ENTREPRENEUR CHARACTERISTICS

	Orientations	Perspectives	Legitimacy	Location	Skills
Orientations					
Perspectives	←↑				
Legitimacy	←	←			
Location	←↑	↑	↑		
Skills	←↑	←↑	↑	←	

Legend: = general causal direction*

3. Institutional role location seems most clearly to be an independent variable in determining orientation/perspective and legitimacy. The impact of role location must be seen in terms of the types of skills that are required in a given role location as well as in terms of skills that might be acquired. It is also possible to think in terms of role location having been determined in response to available skills and orientations/perspectives of personnel -- although this seems less likely from a pragmatic policy perspective.

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* The general causal directions indicated in Matrix 7 are derived from our general knowledge of the relevant literature. In a more complete analysis, we would discuss the relevant literature from which these causal directions are derived. To do so here, however, is beyond our intention of providing an illustrative analysis

4. The legitimacy of the entrepreneur is likely to be determined by orientations/perspectives, skills and role location. Thus to most users, an entrepreneur with local/applied implementation orientations/perspectives, having the perceived necessary skills, and working from an acceptable institutional role location is likely to be invested with the necessary legitimacy to perform the role. An acceptable role location would be determined by the history of prior success and trust generating relations, and perceived authority and appropriateness.
5. In general the variables in the matrix (allowing for the collapsing of the orientations/perspectives set) appear robust and this encourages us to take the next analytical step.

3. Contextual Analysis of Key Entrepreneur Characteristics

We are now ready for a "second cut" contextual analysis in which we will again consider the implications of entrepreneurship across each of the features of the R/D&I system. This time, however, rather than considering entrepreneurship in general (as we did in Matrix 6), we will consider a much more narrow issue. Specifically, we will consider the implications of the interaction between each of the key entrepreneur characteristics (orientations/perspectives, legitimacy, location and skills) and each of the contextual features. At this level of detail, we will begin to see the potential for policy options emerging from the analysis, although some further narrowing in focus may still be helpful. Matrix 8 represents this "second cut" contextual analysis.

MATRIX 8:

CONTEXTUAL ANALYSIS OF ORIENTATIONS/PERSPECTIVES, LEGITIMACY, LOCATION, AND SKILLS

R/D&I System Features	Orientations/ Perspectives	Legitimacy	Location	Skills: Developmental Marketing Need ID & Search Consulting/Service
1. Environment	Interaction with norms & values of users	Interaction with norms & values of users	Economic & political regulations & constraints	Impact of technological requirements and knowledge base
2. Historical Development	Change over time and phases of development	Change over time and phases of development	Observed changes over phases of development	Changing requirements over time and phase
3. Institutional Base		Variation of role legitimacy across institution type Sponsor support Producer/user coalitions	Effect of boundaries, configuration, size	Organizational and inter-organizational skill requirements
4. Goals/Policies/ Strategies	Impact of goal perception differences and interaction with perceived value of the innovation to users	Impact of goal setting processes, goal conflict	Impact of goal difference in various locations	Skills required for varying goals

5. Administrative Processes			Ability to control Ability to mobilize resources	
6. Personnel Base	Motivation & satisfaction		Effect of level of funding constraints on use	
7. Funding	Effect of availability of user resources on entrepreneur motivation		Effect of level of funding constraints on use	
8. Information Flow			Effect of location on place in communications net	Information seeking skills. Effect of on skills needed
9. Innovations				
10. Need Identification	Personal characteristics. Perceived need for innovation	Responsiveness to user demands	Institutional base & position and ability to see needs.	Skills to recognize application needs and potential means of satisfaction
11. Generation/ Research		Constraints on tech. transfer	Location in information flow	Search skills Tech. transfer skills
12. Development 13. Production 14. Marketing/etc.		Differences across functions	Differences across functions	Skills required
15. Acquisition				

16. Implementation/ Utilization	Entrepreneur/user interaction of orientations/perspectives on implementation/utilization	Importance of legitimacy on implementation/ utilization Expected barriers	Impact on linking role. Relation ~~to~~ user entry points	Skills required Interaction with user skills
17. Support services				
18. Evaluation Research				
19. Research on R/D&I				

A preliminary review of Matrix 8 indicates areas that appear especially fruitful for comparative contextual analysis. Thus environment, goals, institutional base, need identification, implementation/utilization and personnel base seem to provide a rich basis for contextual variation across the four areas of entrepreneur attributes under examination. Further, while Matrix 8 has been developed in terms of each of the four selected entrepreneur attributes, we must recognize the interdependencies indicated in Matrix 7.

4. Delineation of Key Factors

With the above comments in mind, we can now identify several unifying factors (or themes) which appear to be critical sources of contextual difference and which can be extracted across all the contextual features as analyzed in Matrix 8 -- but with special attention to environment, goals, institutional base, need identification, implementation/utilization and personnel base.

1. Entrepreneur/user interaction in the values realm
   - Differences (or congruence) in goals
   - Differences (or congruence) with user in perceptions of, need for and value of a given innovation (in the light of available user resources)
   - Differences (or congruence) in orientations and perspectives (e.g.: relative to pragmatism, time horizon, local/cosmopolitan)
2. Entrepreneur/user interaction in the knowledge/skills realm
   - Skills for need identification, search, implementation, and utilization
   - Relativeness to the nature of the knowledge base (e.g.; scientific vs. craft, level of certainty)
3. Environment context of resources and support
   - Availability or limitations (e.g.: amounts, stability, etc.) of funding, personnel, information
   - Sponsorship and constraints
   - Ability to mobilize resources
   - Conflict/cooperation (e.g.: available coalitions for implementation)

4. Structural context of entrepreneur/user relations.
   Linking roles
   Nature of boundaries and organizational configuration
   Institutional size

From this analysis, we can see that our focus is now upon:

1. interaction between entrepreneur/user attributes in the value and skills realm; and
2. the resource/support and structural contexts of entrepreneur/user interaction.

In Matrix 8, we engaged in an exploration of many of the contextual factors that might be expected to be of importance in an analysis of entrepreneur attributes. The above discussion has acted both to capture some (but not all) of the richness of the analysis and to permit us to focus in on a more limited number of policy relevent contextual issue areas. These issue areas may lead us to make determinations about:

1. when and where entrepreneurial activity might be desirable (taking into account goal and value differences between potential entrepreneurs and potential innovation users;
2. skills that are needed (taking into account the entrepreneur/user skill fit);
3. requirements (in the areas of resources and support);
4. institutional and structural characteristics.

5. Interactive Analysis of Key Factors and Entrepreneur Characteristics

The concerns we have just listed would provide the outline for a number of analyses relevant to a series of policy options and programs. However, for the purpose of providing a single illustrative analysis here, we must yet take two more steps: one to further narrow our focus and one to add an extra dimension to our analysis.

MATRIX 9:

ANALYSIS OF SEVERAL ENTREPRENEUR ATTRIBUTES AS DETERMINED BY SELECTED CONTEXTUAL DIMENSIONS

Selected Dimensions of Contextual Conditions	Entrepreneur Attributes			
	Orientations/ Perspectives	Legitimacy	Location	Skills
1. User Attributes 1.1 Values a) Goals-perceptions of value of innovation b) Orientations/ perspectives				
1.2 Knowledge/Skills a) Skills for: -Implementation/ utilization -Need identification and search for the innovation* b) Knowledge base relation				
2. Resource Support Context a) Resources b) Support: -Sponsorship -Conflict/ cooperation				
3. Structural Context a) Linkage roles b) Boundaries c) Configuration d) Size				

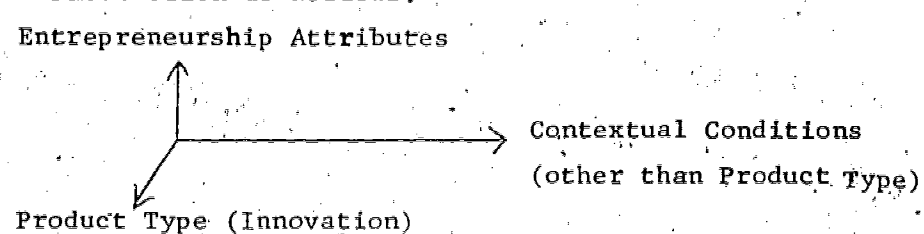
*This implies the skills of knowing what is needed and how and where the need can be satisfied.

Matrix 9 would provide the framework for an interactive analysis of the key factors and entrepreneur characteristics to which we have thus far narrowed our focus from the original larger set of contextual conditions (which we have postulated as being generic to all R/D&I systems).

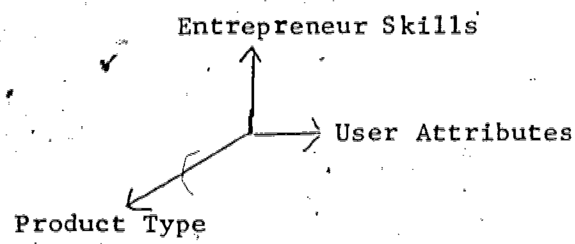
A complete analysis of the issues implicit in Matrix 9 would be very desirable and enlightening, but beyond the scope of our present illustrative effort. Matrix 9 unquestionably contains a sufficient domain for a substantial dissertation. We have therefore, refrained from attempting to fill in the cells of the whole matrix but rather will concentrate now on that smaller portion that has been shaded in the matrix. This represents the interaction between entrepreneur skills and user attributes, but with special emphasis on the skills areas (as being potentially specially susceptible to policy initiatives).

6. <u>Product Type as a Dimension for Interactive Analysis</u>

In addition to the above entrepreneur and user variables, there is one other aspect that we have not yet considered: the <u>substantive content of the innovation</u> that is the subject of the entrepreneur's activities. In the interaction between the entrepreneur and the user, the nature of the product (or innovation) is a potentially critical parameter for the analysis. In this specific case it would, for example, make a great difference if the entrepreneur was promoting a new innovation or a more matured product; whether the product was simple to use and its benefits relatively self evident, or a difficult to use product of uncertain benefit. Thus the innovation (our R/D&I feature 19) in this case is a key factor in this analysis. At a general level of analysis, we might conceptualize the interaction as follows:



More specific to our purposes here, the interaction would be:



II. ENTREPRENEUR VS. USER INITIATIVE IN NEW PRODUCT DEVELOPMENT: AN ILLUSTRATIVE POLICY ANALYSIS OF THE ENTREPRENEURSHIP ISSUE

We have now reached the point where it becomes feasible to undertake detailed theoretical but policy-directed analyses. We have thus achieved our stated objective of following a reductionist methodology (i.e., narrowing our focus to a manageable level), while at the same time pulling with us those critical contextual conditions that will provide a rich level of analysis -- thereby permitting us to deal with a focused (and therefore policy and management actionable) issue in the larger frame of reference.

Further, we have followed a procedure that would enable us to trace back any implications into the total, wholistic framework. This has been indicative of a deductive approach. It is important to emphasize that in practice the selection of an issue area (or areas) might be arrived at inductively. The primary purpose for the matrix analyses in such cases is to fit the analysis into a comprehensive framework and relate it to its relevant context features and to other issues. Also, it should be noted that the general guideline for determining when sufficient detail has been achieved is a pragmatic one -- i.e.: as detailed as is useful to identify and/or deal with specific issues of policy and management concern.

1: The Illustrative Policy Issue: Entrepreneur vs. User Initiative in New Product Development

Let us now proceed by analyzing a significant policy issue that involves the consequences of entrepreneural behavior in the innovation area.

Considerable interest has been recently focused in studies of R&D and innovation on whether the entrepreneurial initiative for new product development and introduction derives from the initiatives of producers or from the initiatives of users (see for example the work of Radnor and Neal,[6] Von Hippel[10] and Abernathy[1]). Thus, in the technical instrumentation case Von Hipple has identified the users (customers) as the prime stimulus source. In contrast, Radnor found the producer to be the prime mover in certain law enforcement equipment cases, with randomness almost seeming to be the most reasonable description of the process in most other law enforcement equipment cases. Abernathy has commented on the fact that as a product area matures (as in the case of automatic machine tools), there may be a shift from user to producer (supplier). Many examples can be cited from the health field of fully cooperative ventures between producers and users (e.g.: Schermerhorn[9]). Of course, we must allow for the possibility of external imposition of innovations.

2. A Typology of Entrepreneur/User Relations

From the few examples noted above, it seems possible to construct a typology of producer (entrepreneur)/user relationships in terms of innovative initiative. Since we are focusing our analysis on the producer as the entrepreneur, the typology in Figure 16 below (and subsequent discussion) will use the term "entrepreneur" to refer solely to producers.

1. Entrepreneur dominated
2. User dominated
3. Cooperative (entrepreneur/user)
4. Externally imposed
5. Serendipitous

FIGURE 16

TYPOLOGY OF ENTREPRENEUR/USER INITIATIVE IN INNOVATION

Given a policy objective to intervene and manage the innovation process, knowledge of the conditions that might lead to and influence these processes would be vital. We are now in a position to connect our analysis thus far to this issue area of innovation initiative in a demonstration of our inductive/deductive process.

From Matrix 9 and our earlier typology of product dimensions, we may see our analysis as involving:

User Attributes

Implementation/utilization skills

Need identification and search skills

Perceptions of the value of the innovation with respect to resources

Product Characteristics*

Maturity of the product

Complexity of the product with respect to user knowledge base**

Entrepreneur Skills

Need identification

Developmental

Marketing

Consulting/service

3. Illustrative Analysis of Outcome under Varying User/Product/Entrepreneur Conditions.

The above scheme can be illustrated by selecting several varying sets of conditions (cases) drawing the partial implications that could contribute to a total study.*** The seven cases we have chosen for analysis are summarized in Figure 17. These seven cases illustrate some of the likely outcomes that can be expected under varying user/product/entrepreneur conditions.

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*Only two dimensions have been selected to simplify the analysis - as relevant others would be required.

** Product complexity here implies complexity in acquisition, implementation, utilization, maintenance, etc. Thus it captures the issue of the nature of the knowledge base that provides the criterion for relative user/entrepreneur skills.

***It is important to keep in mind that the analyses and later derived policy implications are only partial and contributory to a total analysis in that they are limited to the sub-set of variables we have chosen to examine.

Figure 17: Comparative User/Entrepreneur/Product Cases

Conditions / Case	A	B	C	D	E	F	G
User							
Need ID and search skills	Low	Low	High	Low	High	Medium	Low
Implement/utilization skills	Low	Low	High	Low	High	Medium	Low
Perceived value of innovation	High	High	High	Variable	High	High	High
Product							
Maturity	Low	Low	Low	Low	High	Low	High
Complexity	High	High	High	High	High	High	Low
Entrepreneur							
Need identification skills	High	High	Low	Low	High	Medium	High
Developmental	High	High	Variable	Variable	High	Medium	High
Marketing skills	High	High	Variable	High	High	High	High
Consulting/service skills	Low	High	Variable	Low	High	High	Low
Consequences							
Innovation domination	Entrepreneur	Entrepreneur	User	Variable (Serendipitous)	Entrepreneur in large market, otherwise cooperative	Cooperative	Cooperative or entrepreneur for diffused users
Entrepreneur opportunities	High user receptivity to product	High user receptivity to product & service	Receptive user with well defined (designed) product (innov) needs	Naive user	Receptive user with well defined needs	Receptive user with well defined needs able to accept help on implementation	High user receptivity to product
Problems encountered	Low success with implementation & utilization High dependence on entrepreneur for innovation proposals. Leads to frustration	High dependence on entrepreneur for both innovation proposals & for implementation. Can lead to captive relations (Monopoly)	Technology transfer to other potential uses. Size & generality of markets	Low probability of finding fit, attempts to implement inappropriate innovations Highly responsive to external pressures.	Markets can become very competitive. "Not invented here"	May limit technology transfer to other uses. Entrepreneur need identification skills may not develop	Entrepreneur may sell user on innappropriate products. Market may become very competitive

A. The Cases

i. Case A

In Case A we have an entrepreneur with well developed need identification, developmental and marketing skills in relation to the nature of the product, a new and complex one. The entrepreneur understands the user's problems, knows what products are needed, and can deliver them. He also knows how to reach and make the sale to the customer -- but can do little to assist in the implementation and on-going utilization problems of a user who is weak in these same areas and therefore needs the unavailable help. Additionally, the user lacks the competence to be able to identify (or to differentiate between) what and whose products might (or might not) solve his problems -- but sees a high value to any innovation that could help.

As a consequence it is the entrepreneur who dominates the innovation process. He takes the initiative both as to determining the characteristics of the innovative product and as to providing the linkage with the user. In this, an important service is provided to a relatively helpless user -- a user who (because of the great perceived value of the innovation) is found to be highly receptive to the entrepreneur's initiative and product. Unfortunately, that is where matters come to a halt. With a complex product (and given both the user's and the entrepreneur's lack of implementation/utilization skills) we are likely to encounter failures at this stage of the innovation process.* Another continuing problem is that the user continues to be highly dependent on the entrepreneur for future innovations in the same area. The inevitable long-term result is great frustration.

The above is a very familiar scenario. It is interesting that case A does

*For the sake of illustrative simplicity we are restricting these cases to two party situations. In the complex real world there are often more than two key parties to a relationship, e.g.: in this case a partial compensation could come from the existence of competent consultants.

well represent our observations of the two-way radio market for police departments in the case of the unsuccessful (or very much less successful) producers.(4)

ii. Case B

Case B, however, represents the condition for the extremely successful entrepreneur in the same market -- one that has come to capture the bulk of the business in the field. And yet, interestingly, the two profiles for A and B show only one point of departure. In Case B, the entrepreneur has strong (high) consulting/service skills, as compared to weak (low) skills in Case A.*

As in Case A, the entrepreneur is the dominant innovator to a receptive user market -- but this receptivity extends to the service as well as the product area. The entrepreneur now is capable of providing the vitally needed help in implementation and utilization -- possibly setting up technical service functions in an equivalent of an "extension service". As a consequence, success rather than failure attends these efforts; and instead of frustration, we observe a growing productive interdependence. Other users, frustrated by their experiences elsewhere, join the relation, even though they might not prefer to be "captured" by the growing giant. And captured they are. The very "success" of this relationship illustrates its problems. Captive users may become resentful of the increasingly powerful entrepreneur, who sees no incentive to help upgrade the skills of dependent customers. This can lead to resistance and may reduce the great service provided in the field situation upon which the success is founded.

iii. Case C

The same type of product (new and sophisticated) is found in Case C,

*This is not to imply that there may not be other important differences beyond this analysis framework.

but this time it is the user that posesses the critical need identification, search and implementation/ucilization skills rather than the entrepreneur. Now nothing moves until the user: (a) recognizes a need for a specific innovation precisely defined (sometimes even designed) by itself; and (b) initiates a relation with potential producers (possibly in the form of a request for a bid to produce a specified product). Even though the entrepreneur's marketing skills may be valuable in helping to land the contract, it will be the user that will dominate the innovation relation. The entrepreneur's task is made easier, but his ability to make a technological transfer of the innovation to other applications may be limited both by his own possible lack of skills in development and/or need identification and by the control that the user may exert over products of its own initiation and design. Thus, the entrepreneur may be limited in expanding the market size beyond the original user, and the limited market acts as a further constraint on innovation. This is often the situation where highly sophisticated users (e.g.: the large automotive companies or high technology federal agencies) contract out to machinery or instrument makers for a highly specified new product.

iv. Case D

In Case D, we once again find a naive user faced with a new and complex innovation, as in Cases A and B. In some respects, the user is in an even worse condition because he is less clear about the value of the innovation. However, in Case D, the entrepreneur (unlike Cases A and B) cannot compensate for the user's need identification weakness -- he too, is ill-informed on which users need what. Even his developmental skills are suspect; and he can give little implementation and utilization assistance. Under these conditions it would be surprising that users and entrepreneurs manage to find a proper fit. That this does occur of occasion is best ascribed to serendipity.(7)

A problem of significant magnitude is that the considerable marketing skills of the entrepreneur in Case D can lead to users acquiring inappropriate innovations (gadgets and fads) that may squander scarce resources. Outside pressures (for example, from political and lay sources) may be difficult to resist because the user lacks justifiable alternative programs. The world of education and many areas of local government seem to fit this context in various product areas.

v. Case E

Case E mirrors Case C in terms of product and user characteristics -- except that we now observe a mature rather than a new product situation. The difference is significant. The entrepreneurs have had time to learn the business in all its aspects and to become appropriately adapted. This permits them to assume the dominance of the innovation environment and allows them to entrepreneur in a wider market. This is a commonly observed phenomenon, as is the case where a machine builder is able to develop a general purpose (as opposed to a specialized) product that can serve a variety of applications areas. Under large market conditions, problems of over-competitiveness can develop. Many entrepreneurs can learn the business and the highly receptive large market is a major attraction. In some other cases, the constraints of the original application area or the original innovation limit such generalization. In those cases, the entrepreneur lacks incentive and the relation tends towards one of limited entrepreneur/user cooperation.

Another potential problem may arise precisely because of the sophistication of the users. To them, nothing produced on the outside truly measures up to their perceived needs, nor the quality of the product they could produce themselves (but for the constraints of time and cost). This often surfaces in the "not-invented-here" syndrome, with users feeling obligated to rework products that are acquired: to set up idyosyncratic specifications demanding high priced "specials" as opposed to off-the-shelf standard products; and so on.

vi. Case F

Cases F and B are more alike than they appear at first glance on paper. The overall level of available skills between entrepreneur and user are not greatly different, but they are significantly different in distribution in two areas: need identification and implementation/utilization.

In relation to need identification under Case F conditions, the user and entrepreneur find their fit because each has some degree of capability to seek out the other in an area in which innovation is needed and not generally well understood. (A high/high combination for need identification would also have this result, but would generate a greater level of potential independence of the parties than occurs in Case F, where a fit is established.) The parties in Case F need each other because they each have some difficulty in identifying appropriate alternatives. This may be true even when the relationship is less than optimal (e.g.: there may be more competent entrepreneurs around, but a switch may be seen as difficult and/or risky by the user).

Additionally, the user needs some implementation/utilization help -- which the entrepreneur is in a position to provide -- but has a sufficient level of in-house competence to be able to accept help in a productive manner. A cooperative relationship is the obvious consequence. The very comfortableness of the relation may, however, act to constrain technology transfer to other applications and may reduce the incentive for the entrepreneur to sharpen its need identification skills. Long term consulting relationships often have these qualities.

vii. Case G

The final Case (G), unlike the others, involves a mature product of low complexity, but with users and entrepreneurs having the same characteristics as in our first Case (A). In this instance, the simplicity of the product and the long user and entrepreneur experience both facilitate the selection and implementation problems. The technically weakest user can adapt to the product requirements; the relationship becomes more cooperative; and the entrepreneur's domination lessens. This does not guarantee that the user is adopting the proper products, only those to which he has become accustomed. The form of the "cooperativeness" could be a combination of market research (what does the user want) and persuasion (marketing/ advertising). The simplicity of the product may invite competition from small, sometimes low skill entrepreneurs (alley shops) -- unless scale considerations prevent this. In the high volume, mass user cases (consumer industries), the entrepreneur maintains domination due to the diffuseness of the user population.

B. Maturation and the Dynamic Nature of the Innovation Process

Case G and the previous Case E are important in our analysis in another respect. Both represent cases of mature rather than new innovations. As such they depart from our original perspective for this whole analysis, namely that we are exploring the entrepreneur/user relation in the early developmental phase of an R/D&I situation. The comparison of Cases A and G emphasizes the importance of the time dependent maturation process. The learning and mutual adaptation that go on lead to modified outcomes. Even the difference in product complexity between cases A and G could be interpreted, at least in part, as being a shift in perception resulting from learning and adaptation. While it is not necessarily so, one way of looking at Case G is as a more developed or matured form of Case A, with some (though not all) of the problems having become ameliorated. This recognition must reinforce our understanding that the innovation process must be examined as a dynamic phenomenum in which the changing role of the entrepreneur in relation to the user may be of critical importance.

4. A Cross-Sectoral Comparative Case Analysis of OR/MS as an Innovation

A. Some Further Considerations

1. A Contributory Illustrative Analysis

Before going on it is important to keep one point in mind. Entrepreneurship was selected for illustrative purposes out of a larger set of issues. The matching of entrepreneur skills with those of the users was similarly selected. Our purpose has been to illustrate the insight and explanatory power that can be derived from our analytical procedure. It has not pretended to completeness, but rather to being contributory (perhaps importantly) to a total system analysis.

2. The Complexity of Skill Level Variations

Before we leave the analysis of these cases to go on to consider the policy options and management strategies available to deal with the emergent problems, some enrichment of the analysis would be helpful. For simplicity we have categorized users and entrepreneurs as being high, medium or low in any given skill area. In practice it is not quite that simple. A user may have generally high implementation skills, for example, but lack experience in a specific applications area. Such a user is not in the same condition as a user who lacks such skills in all areas, including that of the specific application.

3. Behavioral Consequences of Differences in the Skills Balance

We have also not given full recognition to some of the behavioral consequences of the differences in skills balance. Thus while high entrepreneur to low user implementation skills can be seen by the user as helpful, the balance could (as we noted) also lead to resentment, mistrust and resistance. In turn low entrepreneur skills could lead to lack of legitimacy in the eyes of a highly skilled user (although we did not have such a case among the seven presented in relation to the implementation/utilization skill area).

B. The Adoption of New Management Technology: OR/MS

The specific case involves the adoption of new management technologies in the 1960's to early 1970's -- specifically, operations research/management science (OR/MS and associated methods). This case is taken from empirical observation. In this case the issues just noted above will appear -- as will the dynamic nature of the innovation process which we noted earlier. The case is also interesting in that it deals with an example of entrepreneuring a software (systems or service) application as opposed to a hardware product, <u>within</u> institutions (i.e.: through internal entrepreneurship). The case is given across three sectors: industry, law enforcement and aerospace.

C. Comparative User/Product/Entrepreneur Conditions Across Sectors

In the three sectors, the comparative user/product/entrepreneur conditions relevant to the introduction of OR/MS as an innovation would be approximately as in Figure 18 (using the categories in Figure 18). It should be kept in mind that the empirical studies found considerable variation across institutions in each of the three sectors. Thus, we recognize that there may be a potential for variability from these ratings in any category.

User	Industry	Law Enforcement	Aerospace
Need ID/Search	Medium	Low	Medium
Implementation/Utilization	Medium	Low	High
Perceived Value	Low	Low	High
Product			
Maturity	Low	Low	Low
Complexity	High	High	High
Entrepreneur			
Need ID	Low	Low	Medium
Development (Technology)	High	Medium	High
Marketing	Low	Low	Low
Consulting/Service	Medium	Low	High

Figure 18

Comparative User/Product/Entrepreneur Conditions
Across the Industry, Law Enforcement and Aerospace Sectors

D. A Sectoral Comparison

1. Industry

In big industry, the entrepreneurs of OR/MS methods were (by and large) highly skilled practitioners of OR/MS technologies, were weak in their understanding of user problems, poor in marketing competence, and at best fair in their ability to assist in implementation.(5) In contrast, their clients -- the ultimate users -- were relatively unfamiliar with OR/MS methods, although many of them had considerable knowledge and experience with alternate techniques and approaches to solving the problems involved. They could, fairly quickly, develop an appreciation of application methods, expected outcomes, and (importantly) see the weaknesses of new techniques vis a vis their needs. Initially, users (often with the support of other competitive high skill professional groups -- e.g.: accountants) tended to react more to their perceptions of these weaknesses than to recognize potential OR/MS benefits. The result was an initial clash between the OR/MS entrepreneurs -- followed by an intensive (and generally successful) period of mutual education of users to OR/MS and of OR/MS entrepreneurs to user needs. This led eventually to widespread and relatively successful adoption of OR/MS in the larger industrial firms, with the technologies coming to diffuse widely within these firms.

2. Law Enforcement

In the case of law enforcement, the internal entrepreneurs of OR/MS were themselves, in general, also not very skilled in their technologies. Their clients were even less skilled than their industrial counterparts in either the OR/MS or equivalent techniques. As a result the OR/MS "revolution" hardly got off the ground, and it took the infusion of skilled external consultants in a major role before noticeable progress was to be observed. Until the skill level of the entrepreneurs was upgraded in this way, little in the way of transactions was to be effected in this even more extreme example of Case D above.

3. Aerospace

In a case crossing industry/government lines (aerospace), both OR/MS entrepreneurs and clients were technically very skilled. As a result there tended to be a high level of initial agreement and a limited set of applications were implemented in mutually agreed areas. However extension of OR/MS to other problem areas was limited to continued acceptance and utilization in the early agreed areas, somewhat like the result of the previous Case F situation.

E. Implications

From these cases we might observe that a small entrepreneur-to-user skill gap can have very different results, depending on whether this occurs at mutually low skill levels (as in the law enforcement case) or with mutually high skills (as in the aerospace case). Further, where the entrepreneur has a large skill increment over his clients (as in the general industry case), if the clients start at a high enough level the potential may be excellent for adoption and diffusion, even though there may be considerable initial problems to be overcome -- the clientele is essentially educatable as long as the entrepreneurs are flexible enough to mutually adapt to educated user needs.

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5. Illustrative Analysis of Policy/Management Options Under Varying User/Product/Entrepreneur Conditions

The earlier analysis of seven case situations (Cases A - G) generated a number of policy/management relevant issues within each case situation. This analysis can be pursued further to illustrate some possible policy and management strategies available to the various parties in the R/D&I system. Figure 19 illustrates some of these potential actions which could be taken by the users, the entrepreneurs (producers) and by super-ordinate (general level) policy makers (e.g.: top management in an organization or, in the macro case, a federal agency). This figure shows in each case the results that might be expected if the potential option or strategy is exercised.

i. Case A

The problem in case A was of a low skilled user dominated by an entrepreneur who was unable to assist in the implementation/utilization of an innovative and complex product (and implicitly assuming the unavailability or of third party; e.g.: assistance from consultants).

The user's strategies fall into two general but interactive categories: (1) upgrading its own skills and (2) switching producers/entrepreneurs, if this latter option is feasible.

By improving need identification and search capabilities (which might be done directly or in fact through some form of contracting out as with consultants), the user would be better able to know what products are needed and where to obtain them, thereby creating greater user freedom viz a viz potential entrepreneurs. Improving implementation/utilization skills could increase the success of the innovation activity and again supplements the user's independence. In turn, this independence and the associated improved need identification and search

Figure 12 Comparative Cases: Policy Options and Expected Results

Case	A	B	C	D	E	F	G
User options & Strategies	Improve directly or thru consultants 1. Need ID 2. Impl/util skills Switch to more skilled producer	As in A	Help educate producers in need ID development, service skills	Improve all skills. Increase contacts with more competent users	Engage in personnel exchange programs with other users & producers. Programs to keep close to state of art	Improve need ID & implementation skills	Improve need ID skills
Expected Results	1. More user initiative 2. Improved Impl/util success	As in A	Reduced burden on self. Opens up added sources of innovation. Reduced costs thru larger markets	As in A plus better understanding of application benefits & costs	Reduced provincialism. Avoids creeping obsolescence	Widened range of potential suppliers and applications increased competition among producers	Acquisition of more relevent products and processes. Learns to avoid fads
Entrepeneur options & strategies	Improve consulting/ service skills	If user seeks help can become source of user training as above	Improve skills in all areas. Learn from users	Improve need ID, developmental & consulting/ service skills	Maintain active R/D & I program to stay with or ahead of users	Improve need ID and developmental skills. Aid user to develop skills	Improve consulting/ service skills
Expected Results	Improved implementation success	Wins user's loyalty and help overcome resistance	Increased role in relationship. Opens up new applications (market) outlets	More focussed marketing efforts with more appropriate products. Wins loyal users (customers)	Maintained position	Widened range of outlets for products and services. Wins loyalty of user	Helps lead user into more sophisticated & less competitive products

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Case	A	B	C	D	E	F	G
Super-ordinate Policy Maker Options	Support training & recruiting programs for users in need ID, & implement/utiliz. Help set up consulting & extension services & information systems if unavailable	As in A	Provide incentives for R/D & I programs at selected producers. Create information diffusion (T-U) systems.	Support training programs for users & producers (including joint programs). Help establish information diffusion, standards setting & consulting mechanisms	Encourage interchange programs Encourage producers to enter related fields (markets)	Information diffusion programs to promote technology transfer	Aid establishment of standards & consulting mechanisms Assist user skill development programs
Expected Results	More user initiative. Improved implementation	As in A plus helps wean away users from dominant producer	Wider innovation base. Greater diffusion of innovations.	Higher rates of proper & well diffusion used & implemented innovations. Less fads, more defensible programs	Helps prevent stagnation from complacency & provincialism. Extends capabilities into related areas	Broadened base of innovative activity.	Upgraded quality and relevence of applications

skills makes it feasible for the user to switch to an entrepreneur (if such an alternative is available) that can better supply its needs, with similar consequences for success. If the switch takes place without the prior improvement of user skills, then the danger of becoming captive (as in case B) arises.

The strategies for upgrading in-house user skills would usually involve some combination of training and recruitment of new personnel and contracting out as noted. A partially similar result can be obtained through improving the flow of product and process information on availability, applications and performance evaluation. This is not usually within the power of the user to influence externally. The user can, however, attempt to insure utilization of information which is available (although unfortunately most such users that need the help cannot differentiate between poor and good quality information). Informal relations with other trusted and more competent users is frequently another source of need identification and search information, and properly exploited this strategy can be of great assistance.

The entrepreneur can attempt to upgrade the service and consulting provided by it to users. This would have great benefits to the user making it less necessary to either build individual skills or look elsewhere (although the former response has the already-mentioned problems of leading to user captivity). Depending on the situation this could be a difficult, costly and slow-to-achieve strategy (e.g.: it might require the setting up of a national field service network). In the intra-organizational case it may call for a change of style of operation and the number and type of personnel -- a possibly more feasible if sometimes uncomfortable (and hence resisted) option.

A top level policy group or a government agency attempting to intervene in the case A context should be aware of the leverage opportunities that exist in supporting users in their attempts to upgrade themselves through training and recruiting efforts. Other policy options might lie in supporting the emergence or development of departmental, local or regional information services. A special sub-issue involved in improving the quality of information flow to users which lack necessary need identification skills is the creation of some form of product standards, thereby simplifying the user's decision problems. The creation of improved information services and standards programs are, as we noted above, outside the sphere of influence of most users, but is a most appropriate policy option at the governmental level and even at the organizational level for large institutions.

Support could also be provided to entrepreneurs attempting to build up their skills. Within institutions this may not be a major problem, but at the macro level, governments may be constrained in supporting one producer over another in terms of the effects on competition. Even so, ample opportunities may be available. These could involve the support of model programs designed to assist users on implementation problems, etc., with obvious self training and system spin-off effects. These opportunities could also involve the promotion of joint ventures; e.g.: between organizations with strong development skills but poorer service capabilities and other organizations having complementary strengths and weaknesses (e.g.: insisting that large prime contractors subcontract out implementation and service roles to smaller regional institutions that may survive only because of their strengths in their specific areas). Even the strengthening of a single entrepreneur with the needed skills could act as an incentive to the others to make similar improvements if they are to prevent erosion of their position with clients and customers as these gravitate towards the unit providing the better service.

We must also not lose sight of the fact that, as we noted earlier, we are dealing with a dynamic phenomenon with time-dependent characteristics; i.e., we are looking at an issue that involves an historical developmental process of innovation. To an important degree the problems we are discussing exist because of the emergent and developmental character of the R/D&I process. With sufficient time and a low rate of new introductions of innovation, considerable learning and adaptation can and usually does take place -- although some (or much) of this can be maladaptive and dysfunctional.

Hence one policy option is to do nothing. Over time, even without much help, users will tend to work out a tolerable degree of implementation and utilization (or else disappear) -- and many will gravitate to those entrepreneur/producers that can provide the needed help. Entrepreneurs will gradually learn about the problems of a limited user group, and become more helpful. Depending on how critical the problems are, what other priorities exist, and the feasibility and cost of alternative action strategies, the decision will have to be made to deal with identified problems or neglect them -- with these considerations applying to users, producers and higher level policy makers.

We recognized this earlier when we noted that case G could be considered as synonomous with case A but in a matured form. The differences in context and outcome could be ascribed to the effects of learning and adaptation over time. This strategy (if we can call it that) does lead to solution of some of the implementation/utilization problems; and more cooperation between producers (former entrepreneurs) and users tends to develop, even though some of the basic structural weaknesses remain (possibly to haunt us -- we still see users making inappropriate product acquisition decisions). Case B can also be viewed as a development of A over time. If the outcomes in A are sufficiently frustrating, then some users will also find their way over to a Case B context prior to any real learning and adaptation (if this is feasible -- there may of course not be an entrepreneur with case B characteristics available in any given context). As earlier indicated, to the extent that this can and does occur, it will create an incentive to other entrepreneurs to upgrade their own skills to counteract such a trend, although as we noted this may not always be feasible.

The discussion of policy options and strategies for case A above is based on a perspective that is very different from the one which can be observed in the making of much of current federal government R/D&I policy. Here we typically encounter the situation where an observation is made that a particular context has shown a history of lack of successful innovation. Whether this has been due to an insufficient flow of innovations or a record of poor implementation on the part of users is often less clear. That both of these problems may be derivatives of poor interaction between producer/user skills relative to the novelty and complexity of the applications is almost never considered.

Instead the problems tend to be defined as the result of:

1. a lack of incentive on the part of producers to innovate (to be solved by creating more competition; by subsidizing innovation activity: e.g., by the special purchase of innovative products by government in the hope that this will lead to more general application and diffusion -- as in the ETIP program of the National Bureau of Standards);
2. a lack of capability of producers to innovate (to be solved by having government doing it for them and through various programs of technology transfer and utilization -- e.g.: Technical Utilization programs)
3. a lack of incentive by users to adopt innovation (provide subsidies);
4. an inability to innovate due to lack of resources, information and skills (provide subsidies, pre-packaged programs and model programs);

5. a resistance to adopting innovation (to be overcome by various types of enforcement and sanction processes, inspirational treatments, and behavior influencing and modification programs: e.g., use of participation and feedback etc.).

This is not to say that the above analysis of problems are necessarily wrong or the proposed solutions useless. To the contrary, it is our position that a complete analysis of a situation looking at issues of funding, incentives, capabilities, information flow, problems of implementation/utilization, etc. (as would be the product of a complete study using each of the dimensions of our analytical framework) would turn up the same issues as above, and many more. Rather it is to reinforce our position that only through such a total R/D&I system analysis can one hope to reach into the real causal factors and develop appropriately balanced policy options and management strategies.

It is therefore the objective of our present illustrative analysis and policy derivation effort to demonstrate that there may be critical perspectives that can contribute to the explanation and solution of frequently experienced problem situations -- and that these critical perspectives that tend to be missed without the type of systems perspective and contextual analysis we have been illustrating. It is in this light that the above discussion of entrepreneur/user skills interaction has been presented as a partial contribution to the analysis and solution of outcomes in the innovation process. In the complete analysis the findings and recommendations above would have to be weighed against and combined with alternative and complementary explanations and strategies.

ii. Case B

Case B, as described in Figures 17 and 19, is in most ways the same as Case A -- and most of the previous discussion of Case A need not be repeated here. However, there is one basic difference. In Case B, the entrepreneur is already skilled in the service/consulting skills which are lacking in Case A.

In one sense, no action is called for in Case B. The situation is already favorable to the entrepreneur -- so he will not want to "rock the boat". However, the "monopoly power" position of the entrepreneur leads to user dependence and thus to user resentment and even potential resistance. The alert entrepreneur might thus, within a broader and longer time horizon, attempt to assume the role of helping the user improve its own skills -- thus moving away from a "monopoly power" based relationship. The entrepreneur is even more likely to assume this role where there are signs that users are becoming receptive to such help and/or where other sources (e.g.: the federal government) are initiating programs to make such help available.

iii. Case C

Case C involves a highly knowledgeable user controlling the innovation relationship for a novel and complex product with an entrepreneur with weak need identification skills. The problem here was centered in the limited domain of the innovation base with limited technology transfer to other applications and wider markets. Under some conditions this would be ideal for the user who preferred to be the sole beneficiary of a particular technology. However, the cost might be higher prices for the very specialized product, in monetary and/or personnel effort terms. Thus, to lower costs, a user strategy would be to work with the entrepreneur to make it possible for the entrepreneur to take on the developmental burdens (from the user); to supplement its own innovative efforts with those of the entrepreneur; and to increase the entrepreneur's efforts to reach a wider user group -- hence creating a larger domain for the entrepreneur and potentially lower costs to the user.

- The entrepreneur could (if it saw the wider opportunity) seek to upgrade its skills, including learning from the users (possibly by putting in more than the minimum manpower effort to satisfy the contract). This should result in a gradual shift in the balance of the relationship, particularly if a wider market were emerging which would permit the entrepreneur to invest in relevent competence at a much higher rate.

Super-ordinate level policy makers, especially at the governmental level, could seek to build up entrepreneur competence by providing incentives to develop R/D&I programs and assist in the creation of information diffusion (technology utilization) programs. This could help widen the innovation base and stimulate greater diffusion of the innovations generated by the user.

iv. Case D.

Serendipity was our description of Case D. Naive users were being served by entrepreneurs whose only clear competence was in marketing in a complex and innovative applications area. Clearly there are major benefits to be derived by both users and entrepreneurs in generally upgrading their skills, leading to a better fit between user needs and products and services provided. Users might make special efforts to be in contact with other more competent users, thereby gaining the benefits of their experience with sources and products. With such relatively helpless users, the entrepreneur which does build up its abilities to provide relevent and needed services can hope to win the long term loyalty (and even dependence) of users - in fact converting to a case B type situation.

Support for training programs for users and entrepreneurs (including possible joint programs) could be a useful strategy for superordinate level policy makers. Other options would include the setting up on information diffusion systems (newsletters, magazines, STI systems, etc.), the establishment of standards programs and systems to create common product and performance criteria, and (potentially very important) the creation of consulting and service organizations and groups available to both entrepreneurs and users. One of the indirect benefits of such efforts might be to make innovation programs more defensible and less subject to pressures from outside groups (stockholders, the citizenry, etc.).

v. *Case E*

Case E can be looked at as the end product of the various policy and management programs and the effects of maturation. All skills are high, the product is matured, although in this case (unlike G) still seen as complex. However, as there are no perfect solutions in organizations, the key problem is that of a potential insularity and provincialism that could develop with the Non-Invented-Here syndrome. Each group believes itself too skilled to need the other's help. The objective of policy programs, especially from the perspective of users and super-ordinate level policy makers, would be to encourage personnel and information interchanges to combat these potential problems. Government policy makers and top managers might be especially anxious to diffuse the benefits of the available skills to other areas, again through the interchange and technology transfer mechanisms. From the perspective of the entrepreneur, it is vital to maintain an active R/D&I program to stay with or ahead of users and so maintain position. There are other strategies between such entrepreneurs (such as collusion) that might help them, but these are not usually accpetable (or even illegal in the U.S.).

vi. Case F

The cooperative situation in Case F is comfortable but limiting. Users and entrepreneurs need each other due to their mutual shortcomings but are not necessarily performing at an optimal level. The improvement in need identification, search and developmental skills (as appropriate) can lead the user to wider and possibly better options -- and possibly at the same time stimulate competition and (for the entrepreneur) open up wider opportunities. To the extent that the entrepreneur can assist the user in skill development, this may help to generate future user loyalty. The policy requirements at the super-ordinate role are to help broaden the bases of the innovative activity for both users and entrepreneurs through supporting or creating information diffusion and technology transfer programs.

vii. Case G

Case G represents a potentially matured condition of case A, as we earlier noted. The user's needs now are to grow beyond its present limited perspectives that make it susceptible to the acquisition of gimmicks and fads through development of its discrimination (need identification) skills. Improved implementation skills would add to its independence. These thoughts would be very appropriate whether we were discussing institutional or mass consumer users (the purpose of much of the present consumer education efforts). From the point of view of the entrepreneur, improving service skills could enable the entrepreneur to lead users into more complex applications and products -- and thus out of the matured, low complexity product areas which are likely to be highly competitive. The role of top level policy makers, especially government, would be to upgrade the quality and relevence of applications by assisting users to upgrade their skills, by the creation of consulting and service organizations (e.g.: consumer advice bureaus), and by the creation of product and service standards (e.g.: Underwriters Laboratories, Consumer Reports, Product and Performance Standards in industry, health, food etc.).

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SECTION FOUR

REVIEW AND PREVIEW

Chapter Eight: Conclusion

Appendix

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CHAPTER EIGHT

CONCLUSION

As we noted in the Preface, this report precedes (and includes materials to be included in) later volumes, which will be more comprehensive and will be written for selected audiences: R/D&I system researchers; policy analysts and policy makers; and the educational R/D&I community.

In this report, our intention has been to lay the groundwork for understanding innovation as a total knowledge production/knowledge utilization process; to describe a comparative contextual analytical approach to R/D&I; to provide a basic framework for contextual analysis, and to illustrate how the contextual analytical framework might be utilized to analyze, describe and derive research and/or policy/management relevant implications.

Since the discussion in this report has intentionally been illustrative, there now remain two tasks to be done in order to conclude this report.

First, it will be prudent to "overview" briefly the contextual analytical approach in order to place it in proper perspective. The contextual analytical approach recognizes that innovation involves a total process of knowledge production/utilization; that the various aspects (features and feature issues) of an innovation process interact with each other and thus cannot be adequately understood apart from this interaction; that there are both generic and sector-specific characteristics of R/D&I; and that a concrete real-world R/D&I system emerges from the interaction of generic R/D&I characteristics and a specific sectoral context. Thus, comparisons of R/D&I institutions, systems, and sectors must take into account both the similarities and differences that are the result of an "emergent" process; and analysis of specific R/D&I institutions, systems and sectors must take into account the interactive totality of their contexts.

We have in this report suggested a framework within with such an interactive totality of contexts may be "captured" for use by researchers and by policy/decision makers. It is important to emphasize that this framework is just that -- a framework, a methodology. It does not "give answers" or "make decisions". Nor does it substitute for knowledge about R/D&I, about a specific R/D&I sector/system/institution, about specific R/D&I functions, or about the specific R/D&I issue which is of concern to a researcher or policy/decision maker. Quite to the contrary, such knowledge is a critical ingredient for effective utilization of the contextual analytical framework. Further, the framework specifically allows the utilization of the various perspectives, models, etc. which may relevantly be brought to bear on a particular area.

Chapters Three through Seven of this report have attempted to illustrate the use and utility of the contextual analytical approach. The fact that these discussions have been illustrative presents the second task we must complete in concluding this report -- namely, to give some preview of the usage of the contextual analytical approach in more specific, concrete situations. To accomplish this task, we have chosen to include in the Appendix the following materials:

1. First, we have included a selected excerpt from a recent policy analysis which was prepared by CISST for the National Institute of Education and which utilized the contextual analytical approach.

2. Second, we have included brief summaries of recent or proposed applications of the contextual analytical approach to a variety of R/D&I issues in several sectoral contexts.

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The overall implication of this report which we would emphasize in these concluding remarks, then, is simply that specific R/D&I research and management/policy issues need to be understood in terms of their interaction with the totality of their contexts.

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APPENDIX

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AGENCY/FIELD RELATIONSHIPS IN THE EDUCATIONAL R/D&I SYSTEM:

A POLICY ANALYSIS FOR THE NATIONAL INSTITUTE OF EDUCATION

October 1976

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PREFACE

I. THE CONTEXT OF THE ISSUE

Before beginning our analysis of the appropriate balance between "Field-Initiated and Agency-Directed" R&D, it will be important to frame the issue in its proper context. This can be introduced by a brief discussion of some central questions for NIE today.

What are NIE's responsibilities towards U.S. education in general and educational R&D in particular? How can the Agency utilize a very limited budget for the best short and long term effect, and how might it justify a proper increase in this budget? These are central policy questions, as are such related issues as: the number and types of personnel required within the Agency; the proper place of an in-house Research effort (if any); how NIE should relate to the "Field"; the current priorities for NIE in the "Field"; and NIE's relations with other Agencies that may be playing roles in either educational R&D or in educational practice.

Any attempt to deal with these issues must begin with a recognition of their inter-connectedness. For all its looseness, its inadequacies, there is an educational R&D system to be dealt with and NIE is a critical element of that system. What is done in one area or in relation to one issue will likely affect other areas and have impact on other issues. For example, the build-up of development efforts in the past has had implications for the state of Applied Research and the needs and opportunities for Dissemination now. What the Agency adopts as its mission will determine its budgetary priorities and in turn how it should and could relate to the Field.

The recognition of the current state of educational R&D (including the total innovation process) is as critical as the recognition of its systemic character. It <u>is</u> loose; gaps <u>are</u> characteristic; and inadequacies <u>are</u> all too common. In short, it is a very "immature" and weak R&D system. What then are the implications of these two characteristics of being a system and being immature and weak?

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If education is to be served by a quality R&D system, two major requirements will need to be satisfied. These involve (a) system building, maintenance and protection and (b) system orchestration.

Only futility and frustration can come from policies that ignore the state of the educational R&D system; policies which implicitly assume: viable Research/Development/Dissemination and other institutions which are reasonably well linked to each other and to practice; policies which assume that Users are able to adopt quality R&D outputs, able to properly generate and implement their own significant innovations and able to identify and feed forward their real needs to Developers, etc.; policies which assume that the provision of funds to procure R&D outputs and programs are the primary requirement for success. We suggest, in contrast, that system building, institution building and rebuilding, and personnel development are top current priorities for educational R&D. Further, it is not enough merely to build. A fragile, politically exposed and weak system must be maintained and protected.

A mature R&D system orchestrates itself. Relationships are well developed. Participants know what to seek and to deliver, from and to where, and what to expect and trust. An immature system needs help to grow, to learn how to achieve such a self organizing state.

These are the needs. NIE may not be the largest governmental contributor to the educational R&D establishment, but it is the lead, the core discretionary agency. NIE must take responsibility for the system building and orchestrating. No other body can or will. NIE could walk away or be prevented, politically, from assuming this mission; but the need would remain, as well as the ensuing frustration. In our analysis we have taken the assumption of this mission as a given, along with our premise that there is an educational R&D system, albeit immature and weak.

This sets the scene for our analysis. If we are to understand the factors that determine the what, when, how much and how of the "Field-Initiated vs Agency-Directed" R&D issue, it must be in terms of our understanding of the total educational R&D system as it now is; as we might wish it to become; and as it varies across the differing elements of the system (e.g. as between Research and Development). To do this we need an appreciation of what is fundemental and generic in R&D and what is characteristic of the present educational R&D context.

Such understanding will need development and presentation if we are to be able to deal with the issue at hand. It may, incidently (because of the aforementioned inter-connectedness of system issues) also provide some insight to the type of questions raised at the start of this preface. Some very brief thoughts on those questions may be a fitting introduction and entrée into our analysis.

II. SOME RELATED ISSUES

The limited size of NIE's budget in relation to the needs, and even in comparison to what is being spent in total on educational R&D, is well recognized in the Agency and in the National Council on Educational Research. What are some insights that may be helpful in developing parameters and guidelines for budgetary planning that may be derived from the analysis that we present below?

This is clearly a large policy issue and we can only hope to suggest some useful perspectives in these few comments.

We would need to begin with an evaluation of the capacity of the R&D system, overall and across its parts (or functions as we will be terming them--Basic Research, Problem-Focused Research, Development, Dissemination, etc.). What is there now (in terms of capacity, product inventories, etc.)? What can be delivered? What is needed (capacity, outputs) now and over the longer term? In our analysis we will point out the needs and requirements of the different functions--and how these may differ over time.

Specifically, in our analysis we will note that because of funding policies in relation to the Development function, there are some quality Development organizations and an inventory of Development products. What has been missing have been the quality control function, the Developer/User linkage and the User/Product matching (and tailoring) functions. We will further note in our analysis that the Problem-Focused Research and (until recently) the Dissemination functions have not been well developed and are weak. We will note that overall the educational R&D system is relatively immature.

Given these conditions and the consequent need for system-building, how can NIE best allocate its financial resources? To answer this question requires consideration of several factors. For example:

1. There are inherent differences in funding requirements between functions. For example, both institution building and project costs in Basic Research tend to be lower than for Problem Focused Research which in turn tends to require less funding than Development; i.e. the incremental impact of funding additions and reductions is variable.
2. The time required to build a system will vary across functions. For example, the time required in Basic Research would be quite significantly greater than for Development. Relatedly, so are the time horizon needs and impact of funding changes. Skills take longer to build and the disruption caused by funding variations have much longer consequences.
3. As Sieber (1975) has noted, in the system building process there needs to be a balance in the total system among functions, personnel, institutions, decision makers, and supply and demand.
4. NIE is neither the only nor the largest source of funding for educational R&D. Thus, on the one hand, NIE could attempt to increase its leverage through coordination and orchestration with other agencies to achieve multiplier and synergistic effects. On the other hand, NIE budget allocations might focus on gap filling in areas not funded by other agencies. Thus, it is possible for the NIE budget to reflect cross-agency opportunities as well as NIE priorities and levels of effort.
5. Consideration must be given to the minimal (floor) level of funding needed to maintain quality and stability within a function, and to the maximum (ceiling) level of funding that can be absorbed by a function (given its current state). As we will note, Research system building rates and the ability to spend funds productively is limited by the extent of the existing centers of exellence. Relatedly, funding for system building may need to be concentrated rather than scattered around.

To illustrate how these budgetary parameters might be applied, let us consider what a "balanced" funding process for Research, Development and Dissemination might be, given the existing state of these system functions.

As we noted, a relatively large amount of funding has been provided in the past for Development, while Problem-Focused Research and (until recently) Dissemination has been relatively less developed. Thus, a "balanced" budget plan might be:

1. Since there are now a sizeable number of Development products available, reduce current Development funding--to that minimal level necessary to maintain the existing high quality centers.
2. Since Dissemination has been so recently fragmented, direct significant funding to Dissemination--but not so much as to build a system that would overwhelm Users. At this time, quality control, sorting and technical service would likely need to be a part of the function.
3. Since large scale Problem-Focused Research has been neglected, provide major funding here for system building--but not at a level greater than the capacity of the function to absorb productively.
4. Provide moderate funding for Basic Research, for long-term system-building purposes.

A funding strategy such as the above would, of course, have to consider existing funding realities, political conditions and the particular current needs of Users.

Additional considerations will be important for such a "system building" budget and policy orientation. For example:

1. There must be funding stability over time. System building is a sustained rather than an "in-and-out" process. A three to five year period would be minimal for any kind of system building--and would be completely inadequate in the Research function. For total system building, a much longer time frame is required.

2. System building is different from procurement of a product, and this fact has significant implications for funding policies. For the procurement of a product, open competitive bidding is often a systemically valid strategy because the product (not an institution) is the concern. In system building ing, the reverse holds true--the institutional (and personnel) base is the primary concern--not a product.
3. From the political point of view it may be vital to attempt to educate the relevant communities as to the state of the educational R&D system and to the fact that the next few years have to be seen as a period of long term capital investment--if we are not to be burdened in the future with the errors of the past as we seem to be today. Perhaps this is the only meaningful justification that can be used for added Agency funding that will not return to plague educational R&D in the near future.

These last points warrant further consideration. As we will note in the analysis, system building requires continuity and concentration. Direction and orchestration must be provided from some system-wide agency such as NIE. Thus, Agency efforts cannot be scattered and non-directive and still be effective. This, in turn, implies a tighter degree of selectivity and control by the Agency than would be possible under standard RFP and competitive bidding procedures. Thus, there is a dilemma--there are legal and political constraints involved in a "sole source" approach (which would be a relevant mode of funding for system building purposes).

Thus, as our analysis will indicate, it becomes important for NIE to know what is needed, to be aware of the legal/political constraints, and to find ways to mediate the tension between needs and constraints--i.e., meeting the needs without violating the constraints. Perhaps one mode of such mediation would be for NIE, acting in consort with other agencies facing the same tension, to apprise the Congress and other relevant groups of the long-term requirements for system building as contrasted to procurement approaches to funding, given the current system state and needs.

In the above discussion, we have touched upon two other issues relevant to NIE which are discussed in our analysis: inter-agency coordination and internal NIE staffing (especially the question of an internal NIE Research capability).

Although a detailed analysis and discussion would be beyond our current scope of effort, our analysis indicates that inter-agency coordination and orchestration is a key NIE role--both because NIE is the lead agency in educational R&D and because more funding of educational R&D is provided outside of NIE than by NIE. As we noted earlier, this may at times mean that a significant portion of NIE efforts may be applied toward a specific critical area even though relatively little of NIE's budget is applied to this same area. Stated another way, NIE's focus of concern should be with needs, not only with the implications of its budget per se.

Our analysis also suggests that the way NIE provides for its own internal staffing will have a critical effect on the direction and effectiveness of the Institute. For example, the NIE role of orchestration requires personnel who have skills in orchestration and in facilitating collaboration between people and/or between institutions and agencies. Additionally, NIE will need some personnel who have "political savvy". For another example, our analysis will suggest a need to build the Research function and will further suggest that only by having an internal Research capability will NIE be able to orchestrate the building of the Research functions.

We might also comment briefly on the issue of NIE "rules of ~~thumb" (such as: "only offer a grants competition when a total of~~ one million dollars can be provided and when you can fund 25% of the proposals submitted"). We would not be concerned with the amount and the percentage figures per se. Rather we would note that there is an inherent system logic in such a rule of thumb--i.e., it is correct that the expectations of the field should not be raised beyond reasonable levels of potential for fulfillment. We would further note, however, that "rules of thumb" tend, too often to fall into the trap of ignoring critical system or function dynamics, conditions, needs and requirements. In the above case the danger would be that such a grants competition would be used in an area so lacking in Excellence that the funding of 25% of proposals at the one million dollar total level would tend to trap the Agency into indeed providing the funds to low quality, low-success-probability projects.

One final comment. Our analysis may at first glance appear overly-extended for such a "simple" problem as the Field-Initiated vs. Agency-Directed Issue. Our point is precisely that this is not a simple question--it is embedded within other more fundamental system issues, and NIE's response will have system-wide impact. Thus, the only appropriate analysis is a system analysis. Additionally, this analysis has shed light on other issues confronting NIE--a good illustration of the "multi-purpose effects" concept we will introduce in this report.

III. REPORT ORGANIZATION AND PREPARATION

In the pages that follow, our report will:

1. describe our method of analysis;
2. analyze the NIE/field relationship issue from both the generic and educational context perspectives in four major functional areas of educational R/D&I--Research, Development, Dissemination, and Evaluation Research;
3. outline potential implications of the analysis for NIE policies and strategies in each of the four functional areas;
4. provide hypothetical scenarios to illustrate the implications of potential policy and strategy decisions of NIE.

The policy analysis is framed within the overall contextual issue of the relationship between a mission-oriented federal agency (NIE) and the operative R/D&I community in a specific sectoral context (education in the United States). The specific issue of Field-Initiated vs. Agency-Directed Procurement is treated as a sub-issue of the larger Agency/Field relationship issue.

Reference

Seiber, Sam D., "The Requirements of a National Educational R&D System" in Educational Researcher, December 1975 (p 3-6).

This policy analysis has been prepared by staff members of the Northwestern University Center for the Interdisciplinary Study of Science and Technology under contract # NIE-C-400-76-0110.

The Center is an interdisciplinary Research center that exists to focus the broad and varied interests of a number of Northwestern University faculty concerned with the moral, philosophical, cultural, social, economic, and political significance of science and technology. An area of special concentration is on R&D management systems and problems as they are encountered in a variety of sectors (e.g., industry, law enforcement, and education). The Center brings together interdisciplinary talents from such diverse fields as management, economics, history, philosophy, education, journalism, the physical and biological sciences, engineering, psychology, sociology, anthropology, and religion. Faculty and staff associated with the Center are drawn from several organizational units of the University, including personnel with appointments in the Graduate School of Management, the School of Education, the College of Arts and Sciences, the Technological Institute and others. Center Associates are affiliated with universities and Research institutes across the country and in a number of other nations.

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DEFINITION OF ISSUES AND METHOD OF ANALYSIS

I. ISSUE DEFINITION

1. Initial NIE Concerns

As presented to us by NIE, the concerns of the Agency focused on two questions of procurement policy. Foremost was the question of determining the appropriate balance between "Field-Initiated" versus "NIE-Directed" R&D. The Agency had been receiving considerable criticism from the field, reflecting the view that too limited a role was permitted the field in the design of either broad programs or specific procurements. Many of those unhappy with the present character of procurements were suggesting that the Institute commit itself to a predetermined funding percentage for field-initiated R&D. The expectation was that such a predetermined set-aside formula would create a larger flow of funds into field-initiated work than had recently been the case. The National Council on Educational Research, in its desire to be responsive to the field, requested a review of NIE procurement policies and some careful consideration of the question of how Agency policy might be developed on the matter of the appropriate balance between Field-Initiated and NIE-Directed R&D.

A second, related question involved determining the appropriate mechanisms for procuring Field-Initiated and NIE-Directed work. Of particular concern were questions about the nature and extent of direction that an agency could justify building into procurement mechanisms, specifically with the requirements and language of RFPs (as these might constrain project conception, design, execution, etc.) and most particularly whether the RFP should be used at all in the R&D funding context.

2. Our Reformulation of the Issue

In thinking about these questions, we were struck by the rather fundamental and broad-ranging implications of the questions raised, especially when viewed from the framework of our understanding of R&D

systems and processes. In order to deal with these far-reaching issues in a meaningful way, it seemed to us that there were some critical prior questions to be addressed and clarified. Therefore, we proceeded to reformulate the questions of concern to the Institute in a manner that we felt would best permit us to shed some light and suggest some directions for policy development.

Our consideration began with recognition of two defining features of the Agency's character: first, that NIE is a mission-oriented R&D agency; and second, that NIE is the lead agency for federal activity with respect to Research and Development in education. Given that role, its funding policies would have to be understood in terms of its purposes as these impact on the total education sector's Research, Development and Innovation (R/D&I) system. What the balance of different types of funding should be and how an agency should relate to the field with which it worked would depend on the purposes the agency was trying to achieve across all aspects of the R/D&I system. The nature of this behavior would need to be fitted to whatever it was necessary for NIE to do if it were to achieve its mission in all its R/D&I system aspects. Percentage of field-initiated programs and type of procurement mechanism used could be viewed in this light as indicators or as symptoms of Agency/Field behavior rather than as direct policy leverage points. Therefore, it seemed to us, our analysis could be focused most fruitfully on more fundamental questions concerning NIE's mission and purposes in relation to the field's needs and conditions. Answers to these prior questions, if seen as determinants of necessary Agency behavior, would suggest what the appropriate Field-Initiated/Agency-Directed balances should be at any particular time, and would suggest, too, the most appropriate procurement mechanisms for each individual case. With this set of assumptions as our starting point, we then began to formulate our analytical strategy.

3. <u>The Relationship of this Analysis to Current NIE Analyses of this Issue</u>

In carrying out our analysis the results of recent in-house NIE efforts (specifically the Duffy et al. 1976 memos) were made available to us. We deem it appropriate to point out the areas of similarity and points of departure between our analysis and the NIE in-house report.

A. Review and Interpretation of the Duffy Report

From our perspective, the NIE study was a rich, on-target discussion but one that was acutely limited by its narrowness of focus. We make this criticism on two grounds.

a) The report lacks an overall R/D&I systems perspective, casting its arguments in terms most relevant to the Research function, but far less appropriate to the NIE purposes with respect to, and the generic issues inherent in, such other functions as Development, Dissemination, etc.

b) The discussion was, in our view, more than necessarily couched in terms of a Field/Agency dichotomy (an "us" versus "them" perspective). Rather, it will, as we will show, be vital to recognize NIE's integral place as a part of the educational R/D&I system. Despite these criticisms we would be remiss if we failed to comment on the quality of the analysis within the above stated constraints.

B. Our Approach

By contrast, our approach grows out of and builds on a systems perspective, with NIE's mission being viewed in terms of its impact, as an integral part of the system, on the educational R/D&I system's health, functioning and outputs. Further, growing out of this systems perspective, and as is inherent in our general analytical method, we engage in a broader, more systematic analysis of R/D&I functions and the range of conditions affecting the system. Finally, we note that procurement is but one of the range of behaviors available to NIE by which it can influence the system and that behavior must be evaluated in its totality.

Thus, the essence of ~~the issue~~ as we see it is: how does NIE achieve its purposes through procurements and other Agency actions, taken in consort with and as part of the field?

4. NIE Purposes

A. The Multiplicity of Purposes

Central in determing NIE's proper modes of behavior must be its mission in relation to the educational R/D&I system. While NIE can be conceived as seeking many individual goals these can be usefully grouped under the following general systems dimensions:

1. Substantive outputs of the R/D&I system (knowledge, products, services, etc.) - The systems throughput dimension.
2. System capacity building (institutions, linkages, personnel, etc.) - The level of maturity and capability of the system itself.
3. Affecting the system environment (support, prestige, legitimacy, etc.)- The system environment.

Procurements tend to be thought of primarily in terms of the first of these categories, the direct purchase of R/D&I activities to generate knowledge, produce programs, products, etc., or to provide services. Occasionally, agencies procure capability-building activities directly, as in the provision of institutional support, or the funding of training programs or graduate or post-doctoral fellowships. But for the most part, procurements are designed and managed by agency personnel as individual projects or programs designed to produce specific outputs for the use of the operational system or the R/D&I system itself.

What tends to be overlooked is the extent to which these manifestly single-purpose procurements tend to have multi-purpose implications: in almost every procurement (or other Agency behavior), more than one of these purposes will be involved, whether implicitly or explicitly. Thus, the award of a grant to an R&D institution to support a specific project may also have an impact on that institution's capacity to perform in the future (e.g. by permitting [illegible].

additional personnel, by the added experience that may result). Similarly, the provision of an institutional support grant may result in the conduct of R&D programs whose outputs may not have been specifically sought but which are of considerable value, and at the same time act so as to increase that institution's legitimacy vis à vis various of its publics.

Consequently, it becomes essential for an agency to be very clear about its purposes, those entailing system building and affecting the system environment as well as the use of system capacity to produce substantive outputs. And too, it seems important to develop some recognition of the legitimacy of latent as well as manifest purposes for procurements as well as other Agency actions.

B. Manifest and Latent Purposes

The legitimacy of latent as well as manifest purposes of Agency actions is a point that merits some elaboration. The manifest reason for supporting a particular project may have little relevance to the real reason, which is latent, implicit, and infrequently made clear to members of the R&D community and/or relevant publics. A particular project may receive funding not so much because of the immediate payoff expected from the project itself but rather because of the support it is providing for a certain type or group of graduate students, or because it is expected that if a certain Researcher is supported long enough he is bound to make very substantial contributions to the field. In such cases, defending a project in terms of its manifest purpose may be difficult, but justifying it in terms of long-term capability-building needs may be much less of a problem. Or to consider a somewhat different example, an agency may be subjected to considerable pressure to support a particular kind of program, and the pressure may be substantial enough to have serious enough ramifications to jeopardize achievement of important objectives. In such a case, an agency may have little interest in the manifest purpose of a project, but may support it for the latent purpose of relieving undue stress on the system.

The essential point here is that procurements may provide the greatest long-range payoff if they are designed with multi-purposes in mind, and if Agency personnel can design them creatively to serve latent as well as manifest purposes. What would seem to be needed, then are deliberate Agency strategies to capitalize on the multiplicity of consequences from specific Agency actions, to maximize possible gains and minimize possible costs from potential multiple and interaction effects across the latent and manifest purposes of given procurements.

C. Interaction Effects

This issue of interaction effects is one of the most critical points that seems to be overlooked in the development of Agency policies. Once an Agency comes to view its behavior in terms of interactions among seemingly discrete actions, an entirely different kind of understanding emerges of the potentially far-reaching systemic implications of individual decisions and policies. Different purposes can interact with one another (a point we shall return to shortly). Purposes can interact with procurement mechanisms -- e.g., a mechanism used to procure Basic Research outputs can have major implications for long-term capacity-building. Purposes and mechanisms can interact with contextual conditions, e.g., the state of development of the system; a strategy that may have been ineffective a decade ago may be highly successful in achieving certain purposes now or ten years from now.

The point is perhaps made most clearly by examining potential interaction effects among purposes, both within a single procurement and across the totality of procurements made by an agency. A procurement can lead to the creation of outputs and lead to an improvement in the system environment. Or, it can lead to a deterioration in the environment if, for example, that particular output is seen as offensive to certain key elements. It could also lead to a destruction of R/D&I system capacity by, for example, moving critical resources away from their most productive areas of application.

When one examines patterns of Agency actions across procurements.

i.e., when one considers potential interactions among the discrete procurements that make up an agency's "portfolio" -- interactions of an even less obvious nature become apparent. Across programs, the outputs may reinforce each other (synergistic effects). Or they may counteract each other in the manner of what might be called "anti-purposes" -- i.e., taking a specific action in pursuit of one purpose may make more difficult the achievement of another purpose. The use of RFPs to procure certain kinds of Research, for instance, might well have anti-purpose effects if a by-product is turning off the best Research talents, suggesting to them that Research funding in the field of education is unlikely to be forthcoming without untenable constraints. Such effects may be immediate in their interaction or observable only in lagged and in second- and third-order manifestations. If an agency decides to design procurements that are deliberately multi-purpose in nature, it becomes essential for agency personnel to have a clear understanding of the kinds of procurement "add-ons" that tend to be congruent vs. incongruent with each other, functional vs. dysfunctional.

Portfolio effects may be discernible within institutions as well as across institutions. It is common to observe how R&D institutions become shaped by the patterns of funding that become available to them. If a single agency provides a particularly large share of an organization's total funding, agency actions can have the effect of molding or changing the very character of such organizations.

In summary, then, interaction effects will need to be considered in terms of their:

- synergistic effects
- congruency/incongruency with each other
- lagged (and indirect/second and third-order) effects
- cumulative effects within and on institutions and personnel

The essential point is that multi-purpose effects are inevitable. The issue is not whether there should be multi-purposes but rather whether they are to be recognized or ignored, and if recognized to be dealt with and capitalized upon or anti-purposes minimized.

5. The Functional Context of NIE Purposes

Up to this point, we have considered three sets of purposes that can be affected by procurements and other Agency behaviors. We turn now to consideration of the second major building block of our analytical approach.

NIE's purposes are achieved through the carrying out of various activities that can be categorized by R/D&I functions: Research, Development, Dissemination, etc. Achieving the same purposes (e.g., institution building or affecting the system environment) may call for different Agency behaviors in relation to these different functions. Building Research institutions may demand strategies very different from those required to build Development organizations. The mechanisms that are appropriate for procuring Development products may be quite inappropriate for procuring Basic Research studies, and so forth. Similarly, the types of skills and experience required within NIE to work with personnel and institutions involved in Basic Research are likely to be rather different from those required when working with those involved in the Dissemination function. Therefore, it follows that the determination of Agency behaviors (of all kinds) are likely to be highly dependent on the R/D&I functions with which they are involved, and this consideration must be reflected in our policy analysis.

To make such analysis possible, it was necessary for us to select a set of R/D&I functions that seemed to be reflective of the bulk of the activities that go on within educational R/D&I and that become the object of NIE procurement and other Agency activities. With this in mind, we selected the following R/D&I functions (or groupings of functions)to become the focus of our analysis.*

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* In the R/D&I systems analysis scheme we use generally, we treat Need Identification as a discrete function. In education, however, where specialized Need Identification mechanisms tend to be lacking, Need Identification is carried out as an integral part of each function. We have therefore treated Need Identification this way in our policy analys

A. Research

Research can vary along a series of multi-dimensional continua, generally categorized as going from Basic to Applied. We fully recognize the debate involved in such categorization and the difficulties involved in the usual over-simplification so implied. Nevertheless there are, for our purposes in relation to discussing appropriate Agency behavior, important potential differences between what is required to deal with Basic Research, which is largely involved in the search for knowledge for its own sake, and what is required for applied work that goes on in relation to well-defined problem areas. We will therefore examine these two types of Research as being representative of the range of activities with which NIE may become involved. In thinking through the implications of our analysis for the particular kinds of Research NIE procures, Agency personnel can make the necessary accommodations to variations encountered between these two extemes. The two sub-functions therefore will be:

1. Basic Research (the seeking of knowledge for its own sake).
2. Problem Focused (or Applied) Research. As used here and later in this analysis "problem" refers to a social or practice-centered problem rather than to the kind of intellectual or discipline-based problem that is central to Basic Research.

B. Development

Whereas what we are calling Problem-Focused Research is oriented toward problem areas within education, Development work tends to be focused on the design and elaboration of products, processes, programs, procedures, practices, etc. that attempt to deal with identified problems or needs. For simplicity of usage, we will generally use the term "products" to describe the outputs of the Development process. However, it should be understood clearly that we have the full array of Development outputs in mind -- programs, procedures, strategies, practices, etc. as well as the narrower category of outputs generally thought of as "products."

C. Dissemination/Implementation/Utilization

The functions within this cluster are typically treated separately in R/D&I systems analyses (at least as between Dissemination and the other two). We will link them in this analysis since this is a characteristic of the educational R/D&I system: its relatively low level of maturity and the general absence of institutionalized integral User change agent functions make this a necessity. The focus of our analysis will be placed on the Dissemination function, since it is here, in system-level linkages (rather than within the User setting that shapes Implementation/Utilization), that NIE efforts can have more substantial impact. However, it should be noted that any future expansions of our analysis should involve specific detailed analysis of the Implementation/Utilization functions.

D. Evaluation/Policy Research

Evaluation and Policy Research are often grouped together. In education this seems particularly fitting since Policy Research in education so often involves one or another form of Evaluation Research. However, there are important differences between Evaluation Research and Policy Research, and they may require some extended separate treatment. Since it appears that the bulk of NIE's efforts in these areas are more directly involved with Evaluation Research, we will focus on this function in our analysis. Again, further work could expand on the specific issues related to Policy Research.

6. R/D&I System Context

We have seen up to this point in the analysis that achieving the same Agency purposes may require somewhat different Agency behaviors in relation to different R/D&I functions. But beyond this, for R/D&I functions and their generic requirements to be understood in terms that seem congruent with concrete empirical reality, it becomes important to see each function within a total R/D&I system context.

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We define an R/D&I system context as the joint interaction of three elements:

1. the R/D&I functions, as described above.
2. operating conditions within a particular R/D&I system (e.g., the maturity of the system; the types and quality of personnel available; the types and quality of the institutions available; the state of development of the knowledge/technology base; the nature of the information systems and flows among key elements in the R/D&I system--journals, invisible colleges, conferences, etc. etc.; the very nature of the innovations involved).
3. the system environment (e.g., the political/social environment, especially its supportiveness or lack of support for the system; the economic environment; the nature of the knowledge base of the field -- whether it is a natural- or social-science base; etc.).

Therefore, in determining appropriate Agency behavior for achieving a certain purpose it becomes vital to be cognizant of both the system function to which it applies and the manner in which the generic characteristics of a given function are mediated by systemic and environmental conditions. It is this joint effect that we term the R/D&I system context.

7. The Spectrum of Agency Behavior

A. Types of Behavior

While an agency such as NIE can engage in a wide variety of behavior in relation to its purposes, these can be usefully grouped for analysis under three headings:

1. Procurements

An agency's use of the funds available to it to procure specific outputs, institution building, etc. is generally seen as the prime forum for Agency action.

2. Non-Procurement System Behavior

The potential range of Agency behaviors is not necessarily limited to procurements. It may also play a potentially important role in the system through a variety of other kinds of actions. These may include: working with other agencies so as to achieve synergistic and multiplier effects from joint (additive and/or supplementary) activities; having its personnel play an active role as members of the R/D&I community--as Researchers, as participants in conferences, as influences on thinking in various informal interactive modes, etc.; by making information available; etc.

3. NIE Internal Actions

How an agency relates to a field will be importantly determined by what goes on within the agency. Specifically, the strategies and modes of behavior required will be constrained by the extent to which NIE has the number and type (skills, experience, stature) of personnel needed and the organizational and budgetary structures that permit appropriate behaviors.

B. Types of Strategies

Within the above three areas for NIE behavior, there remains a wide and multi-dimensional variety of behaviors in which an agency can engage. These can be condensed along three dimensions:

1. Degree of Agency Control

NIE might see the need to maintain a greater or lesser degree of control over what goes on in the field, in terms both of extent (level) and of domain (program selection, methods used, personnel involved, nature of relationships, forms of reporting,etc.).

2. Degree of Agency Involvement

NIE might choose to be more or less directly involved in what was occurring in the field--for example: NIE participation in the various functions (e.g., undertaking various types of Research, Dissemination, Evaluations, Policy and R&D system studies); planning for and monitoring of the R/D&I system; determining what work to carry

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out internally and what activities to procure through external contracts or grants.

3. A Strategy Continuum

Seen the above ways, it is possible to array very roughly the types of strategies by which an agency can relate to various aspects of a field. Such an array could be the following:

- Initiate activity for a field
- Supplement what is already going on
- Modify what is already going on
- Select from among what is already in a field
- Educate the field to operate differently
- Mediate external pressures on specific field elements or programs
- Integrate programs, institutions and systems to be found in the field
- Cooperate with other programs (e.g. in other agencies) or with field programs
- Facilitate activity already going on
- Execute activities initiated by the field
- Evaluate activities that have occurred in the field
- Monitor what is going on.

This array, while admittedly rough, represents, jointly, a diminution of Agency control and involvement in what is going on in the field, in both pragmatic and systemic terms. The order is not, however, especially important. To the extent that it does array a variety of possible strategies, it demonstrates a richness that goes well beyond the simple Field-Initiated vs. Agency-Directed continuum. From our perspective, the Field-Initiated vs. Agency-Directed continuum is likely to be most meaningful in relation to individual projects and programs rather than system-based purposes, and in relation to those functions in which programmatic activities can be separated easily from system activities, at least in the short run, as in the case of Research, especially Basic Research.

(And even then the extent to which the FIS vs NIE continuum applies seems related to the extent to which Agency personnel focus on their own individual projects rather than the system as a whole.) The Field-Initiated vs. NIE-Directed continuum is likely to be far less meaningful for such inherently systemic functions as Dissemination, or for system building purposes. Seen in this way a determination of the proper proportion of NIE's budget that should go to Field-Initiated activity could only be made in relation to NIE's agenda, as it played itself out with respect to the Agency's purposes, as manifested in the various R/D&I functions (Research, Development, Dissemination, etc.) under the prevailing contextual conditions (personnel, funding, maturity of the system etc.). As an overall index it would therefore not seem to provide much meaning, and hence not represent a proper actionable policy criterion.

8. A General Analytical Model

As implied above, our analysis will involve the specification of the behavior appropriate to the achievement of Agency purposes in the context of the functional, systemic and other environmental conditions that prevail. Diagrammatically, this can be illustrated as in Figure 1. This model also indicates that NIE's purposes will themselves be influenced by what is going on in the educational R/D&I context and that in turn this context will be importantly influenced by how NIE does actually behave, as an integral part of the educational R/D&I system.

II. METHOD OF ANALYSIS

1. General Methodology

A complete analysis would require examination of how the interaction of NIE's purposes, as manifested in the R/D&I functions, and mediated by the systemic and environmental conditions, determine appropriate Agency behaviors and consequently strategies in relation to the field. The above statement would imply at least a four

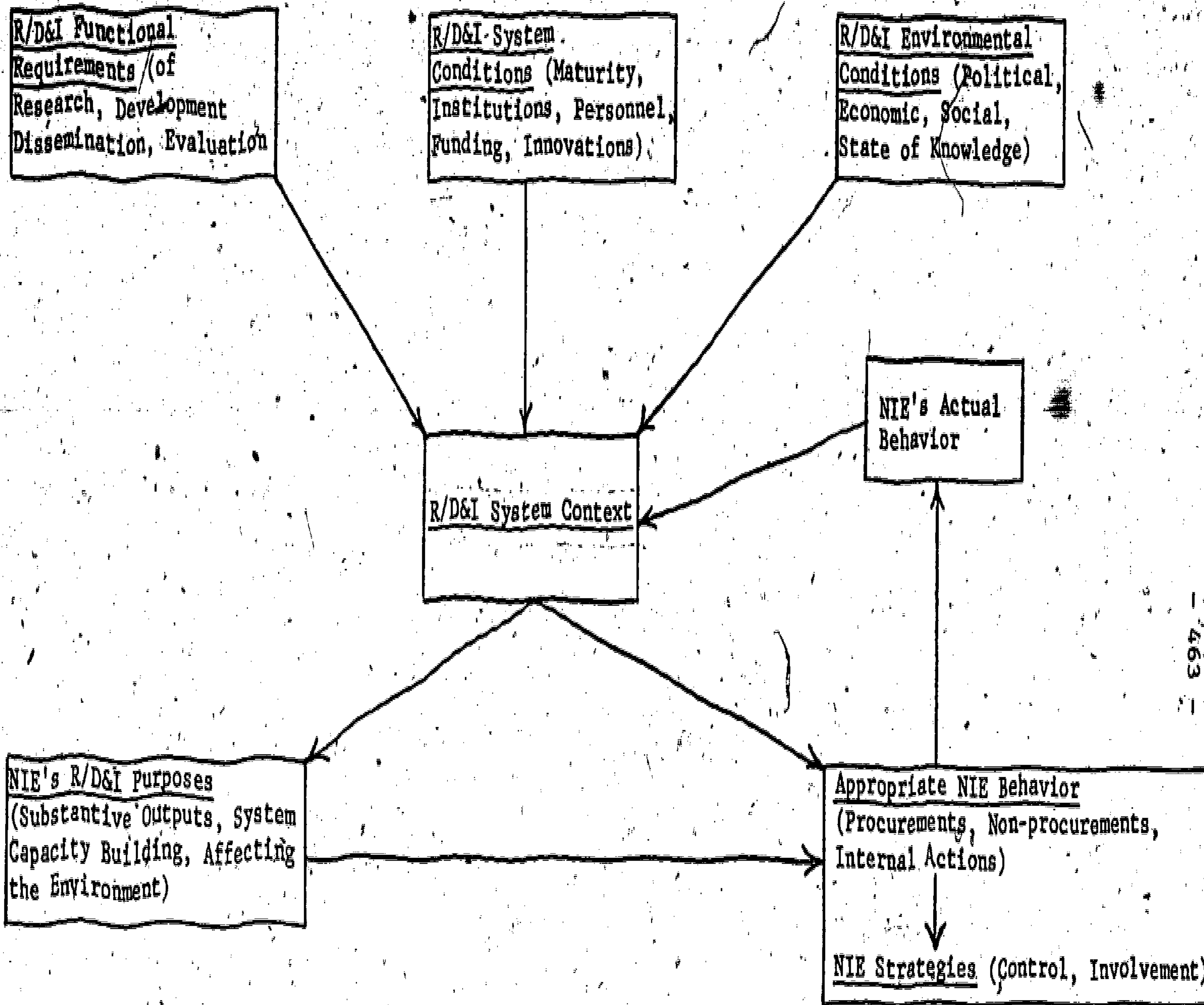

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Figure 1. Appropriate NIE Behavior as a Function of NIE Purposes and the R/D&I System Context

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dimensional analysis. As a simplifying step, we have elected to consider each of the R/D&I functions separately in relation to the combination of R/D&I systemic and environmental conditions, as shown in Figure 2.

	R/D&I Environmental and Systemic Conditions
R/D&I Function	(Appropriate NIE Behaviors/ NIE Strategies)

Figure 2. Simplified Analysis Matrix

The cells of this matrix are the appropriate NIE behaviors which can be built into strategies that the Agency could pursue.

Having conducted the individual analyses for each R/D&I function, it becomes possible to consider the implications for NIE strategy across the functions. Finally, the strategies can be converted into scenarios in which patterns of hypothetical, or actual past or contemplated NIE behavior, are analyzed to suggest likely impacts if implemented as originally formulated, or as reformulated in alternative ways that take into account some of the points we have tried to underscore in our analysis. In the final analysis, one could conceive of converting NIE's total programmatic agenda into an integrated set of scenarios, determining the various patterns of appropriate Agency behaviors (a fallout of which would be an estimate of the percentage of all procurements that would be Field-Initiated--though as we have stated this would not be an index of great significance in an of itself), and suggesting likely impacts.

2. Specific Analysis Method

Within the framework of the above general approach, the procedures to be followed will be as follows:

A. Functional Analyses

Each selected R/D&I function (Research--Basic and Problem-Focused--Development, Dissemination, Evaluation) will be analyzed in the following manner:

1. Generic Characteristics of the Function

We will begin each functional analysis with a review of those generic issues inherent in the function which are likely to be of relevance to educational R/D&I and have implications for NIE behavior. A complete generic review of each function would inevitably deal with many issues that are of relatively lesser concern in education at this time. Given the constraints of time, volume and salience implicit in a policy analysis, we have attempted to be judicious in our selection of issues to be discussed.

2. The Educational Context of the Function

We then consider the current state of affairs in the educational R/D&I system as it relates to carrying out this particular function. We examine contextual issues pertaining to the state of development of the relevant knowledge base, the institutional base, the personnel base, the climate of support for funding its activities, etc. As before, the implications for NIE behavior are drawn. Where feasible, this section concludes with some general guidelines for NIE's operating modes and strategies.

3. Implications for Agency Behavior

In this final section of each functional analysis we attempt to summarize the requirements for NIE behavior in relation to the particular function in its present context, building up some recommendations for Agency strategy.

B. Cross-Functional Analysis

In this critical chapter, we take the analysis and strategy-building a step higher by attempting to draw the cross-functional implications for NIE at a total Agency level.

C. Scenario Analyses

Two illustrative scenarios are then analyzed. Each scenario consists of a description of a hypothetical NIE behavior (e.g., a particular procurement program, its objectives, the manner of its implementation), an analysis of its wide implications (if any) and likely impact, our recommendations as to what changes might (or should) have been made, and the likely consequence of these recommendations. The thinking behind this process is depicted graphically in Figure 3.

A specific NIE action (usually a procurement), with its intended purpose, would result in some consequences. The effects or impacts would be a consequence of the NIE action interacting with contextual conditions, and would have to be understood in terms not only of the intended and manifest purposes of an action, but also any other (possibly latent) purposes. These impacts would be evaluated and appropriate strategy alternatives recommended. Such recommendations would lead to NIE actions involving procurement, non-procurement and internal NIE behaviors, in relation to the whole range of possible purposes. Then, in turn, the effects of these behaviors would be analyzed.

The scenarios are intended to suggest an analytical approach we view as appropriate for internal Agency use in designing procurements and relating procurement strategies to other, possible non-procurement courses of action. The strength of this approach, we would argue, is the manner in which it orients Agency personnel toward system-level thinking:

1. It requires the analyst to think in terms of the multiplicity of purposes implicit in procurements and other Agency behaviors, and suggests the legitimacy of designing courses of action in terms of latent as well as manifest purposes.
2. It requires consideration of interaction effects among purposes, between purposes and mechanisms, and between

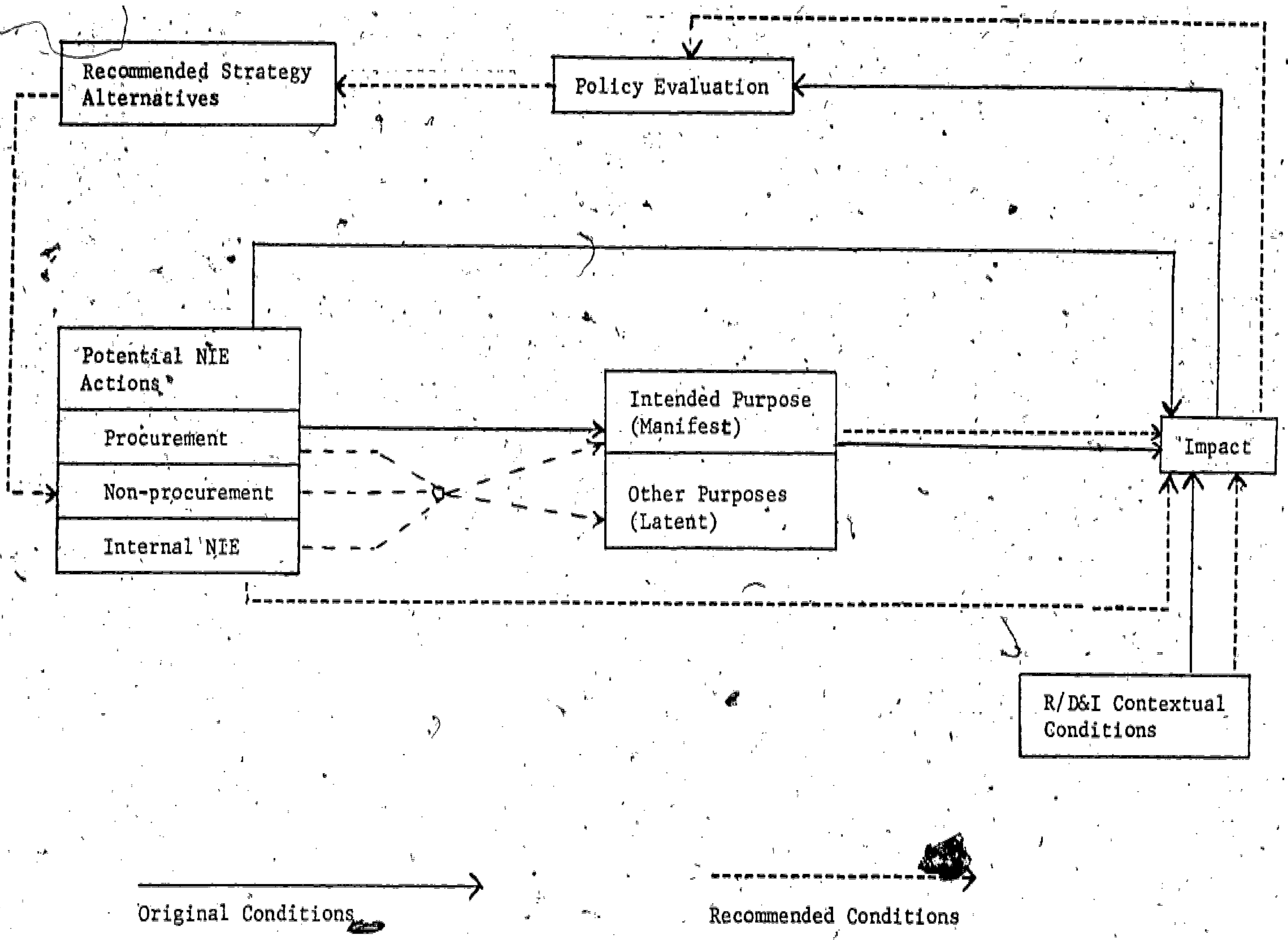

Figure 3: Scenario Analysis

purposes and generic characteristics of R/D&I functions as these are mediated by systemic and environmental conditions.

3. It calls for Agency personnel to estimate potential impacts of contemplated courses of action on key dimensions of the system.

4. It suggests a series of questions that enable the analyst to generate alternative courses of action with potentially different impacts, and to use these alternatives, along with their own estimates of potential impacts, to reformulate and refine contemplated strategies.

We offer the analysis which follows as a first-cut at what we believe can evolve over time into a highly useful approach.

REFERENCES

Duffy *et al.*, 1976.
We had access to several internal memos, in various states of their development, in August and September 1976, including: a) an August 2, 1976 memo written by Susan Duffy and Noël Brennan entitled "Status Report on FIS"; and b) a somewhat later set of materials providing working definitions of Narrow and Broad FIS, elaborating the relevant dimensions of each, and considering some of the implications for NIE.

STUDIES AND ACTION PROGRAMS ON THE LAW ENFORCEMENT EQUIPMENT R&D SYSTEM: EVALUATIVE STUDY OF THE EQUIPMENT SYSTEM IMPROVEMENT PROGRAM

This project represents the initial efforts of CISST to develop and utilize a contextual analytical approach to R/D&I. Thus, it was the precursor to the contextual analytical framework we later developed and which is presented in this report.

This project was a nationwide, 1-1/2 year empirical study of the R&D system for innovation in law enforcement equipment. The project required (in the first phase) that we familiarize ourselves with the law enforcement context in order to obtain a general perspective on the key issues that were to be investigated in the main empirical phase. In this first phase, we established a library of several hundred items (as well as accessing materials available in the Northwestern University Transportation Library); consulted with some twenty persons knowledgeable about law enforcement equipment; and conducted survey research through interviews and general questionnaires for users, producers and distributors of law enforcement equipment. This initial phase of the research culminated in a workshop attended by ESIP advisory board members and NILECJ-ESIP personnel as well as CISST project members from all over the country.

The main empirical phase was conducted in the following manner. Critical policy issues and specific problems in the law enforcement equipment R&D system were identified from the research of the first phase and were synthesized into eight issue areas. With the assistance of law enforcement equipment specialists, ten law enforcement equipment items (representing a broad range of both law enforcement functions and equipment types) were selected for intensive, in-depth case analysis in a matrix format across the eight issue areas. Interview survey questionnaires were then developed for producers, for users, and for intermediary organizations and distributors. Interviews were then conducted with: 71 of 111 identified producers; 47 user organizations; 12 intermediary organizations; 8 distributors. Interviews were conducted nationwide by CISST personnel located throughout the country. From the survey, relevant R&D issues and policy options were identified in terms of the selected equipment types, the selected issue areas, and the law enforcement R&D system.

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PROJECT AND PROGRAM DEVELOPMENT BASED ON A CONTEXTUAL ANALYSIS OF ENERGY CONSERVATION R/D&I SYSTEMS: A POLICY ANALYSIS FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, INDUSTRIAL ENERGY CONSERVATION DIVISION

This analysis has its origin in an NSF funded project in cooperation with the Division of Industrial Energy Conservation of the United States Energy Research and Development Administration (ERDA). The initial objective was to demonstrate the feasibility of using the comparative R/D&I systems framework developed in analyzing two policy issues in the area of industrial energy conservation R/D&I. The specific policy issues for analysis were defined by staff members of the Industrial Energy Conservation Division of ERDA in cooperation with NSF's Division of Policy Research and Analysis and the Northwestern research team. These were as follows:

1. What are the energy conservation R/D&I system factors which ERDA should consider in evaluating specific proposed new technology programs?

2. What are the dimensions of venture analysis (or "impact analysis") which ERDA should consider in evaluating specific new technology programs?

This study is being organized in two parts. The first concerns itself with the analysis, planning, and implementation of industrial energy conservation <u>programs</u>; the second with the parallel flow of <u>projects</u> within these programs. A program is more accurately defined as an energy conservation opportunity area (ECOA) sufficiently broad so as to encompass several discrete projects. These projects, in turn, may encompass one or more phases of the R/D&I innovation cycle from initial need identification to final utilization. The projects in a given ECOA may also vary considerably in the extent to which they are linked together.

At the program level, the basic strategy of the industrial conservation effort is visualized as being formulated so that projects may be selected and contracts negotiated in accordance with ERDA objectives. Similarly, with regard to implementation, at the program level the guidelines and methods of executing projects and utilizing their results in industry are conceptualized as being developed so that at the project level they may be utilized to monitor and evaluate projects. This conceptualization is roughly in accordance with the way the Division of Industrial Energy Conservation is now operating, except that there is considerable variation in the extent to which these phases and levels of managerial and organizational activity are systematically designed and integrated in an overall scheme. In essence, it has become a matter of developing a contextual system analysis at both the program and project level through all phases of technological innovation requiring an input from the Division of Industrial Energy Conservation.

DESIGN/TESTING OF SURVEY ITEMS ON ORGANIZATIONAL CAPABILITIES FOR R/D&I FUNCTIONING

This contract required that we do the conceptual and design work and some field testing for a set of sector-specific survey instruments to assess levels and distribution of organizational capabilities for specific kinds of R/D&I activities. We conceptualized each of four areas of R/D&I functions (research, evaluation research, development, and dissemination/utilization) in terms of key dimensions useful for distinguishing among types of work respondent organizations had carried out, scale and scope of operations within each type of activity. We then designed sector-specific variants of the basic instrument geared to differences in functional emphases among sectors surveyed (academic, private, SEAs and ISAs). Informal field testing of the instruments was conducted, using respondents selected from these sectors. Based on the field test results, recommendations were made about: (a) additional conceptual and design work to be done; and (b) how the instruments might be used in a research program focused on assessing organizational capabilities for educational KPU and policy planning for system capacity building.

ASSISTANCE TO NIE IN PREPARATION OF THE NCER ANNUAL REPORT TO CONGRESS

Under the terms of this short-term contract, CISST personnel drafted a chapter for inclusion in the NCER annual report to Congress. The chapter describes and assesses development of the educational R/D&I system's capabilities over the past two decades (its institutional base, personnel base, outputs, linkages to educational practice, funding, knowledge/technology base, and R/D&I management/policy know-how); analyzes the current status of key R/D&I functions (research development, dissemination and evaluation research); and suggests critical system needs that might be addressed through federal policy initiatives.

A POLICY STUDY OF THE EDUCATION R&D

DISSEMINATION AND FEEDFORWARD SYSTEM

(RESEARCH AND DEVELOPMENT EXCHANGE)

This project involved CISST providing consultant services over an approximately five month period to a planning group for NIE's program for developing a Dissemination/Feedforward System (Research and Development Exchange). The planning group consisted of personnel from NIE-sponsored educational laboratories and centers and staff of NIE's School Practice and Service Division, Dissemination and Resources Group. The work required a multi-pronged approach, including: creating a conceptual scheme that would aid NIE and the planning group in analysis of the system being developed, in identifying critical issues and in generating policy options; meeting with and making inputs to the planning group during their planning meetings; developing a conceptual scheme that would permit NIE to monitor the health and functioning of the system; developing an overall analysis of requirements for educational R/D&I dissemination and feedforward (using our contextual analytical framework); jointly selecting with the planning group a sub-set of issues for further in-depth analysis; selecting and monitoring a group of consultants (with known expertise in the selected issue areas) to prepare analytical papers on the selected sub-set of issues; preparing a final report integrating the above work.

IMPLICATIONS OF REGIONALISM AS AN APPROACH
TO EDUCATIONAL R/D&I: A POLICY ANALYSIS
FOR THE NATIONAL INSTITUTE OF EDUCATION

This project (currently in process) is another project being done to illustrate the utility of the CISST contextual analytical approach for policy analysis of issues of current importance to the National Institute of Education. The issue was jointly selected by NIE and CISST. The analysis will require collection and examination of current activities, policies and other relevant materials from various actual or potential participants in regionalized education R/D&I (e.g.: NIE, NIE-sponsored educational R&D labs, SEAs) and field interviews with various participants. The project will require comparative contextual analysis of the implication of various types of regional approaches (e.g.: development/support of informal regional networks and collaborative activities; creation/support of NIE-sponsored regional organizations; etc.) in relation to key educational R/D&I issues; in relation to specific R/D&I functions; in relation to the current state of development of the educational R/D&I system; in relation to contextual operative conditions (e.g.: funding, the personnel base, currently existing educational R/D&I organizations, legal/political environmental conditions); in relation to the mission of NIE. The project will require development by CISST of the conceptual framework within which information may be gathered, contextual analyses may be made, and policy/strategy implications may be made. CISST will suggest potential policy/strategy options for consideration by NIE.

A COMPREHENSIVE CONTEXTUAL APPROACH TO DEVELOPMENT AND THE ROLE OF TECHNOLOGY IN DEVELOPMENT

The issue of development has been receiving increasing attention over the past few decades from governments (in developing and developed countries), agencies and other organizations. A variety of interactive causes of this interest can be identified, including increased population (accompanied by increased unemployment and underemployment) and decreased per capita income (accompanied by increased income distribution disparities). Other dynamics contributing to this growing interest have been the attainment of independence by numerous previously colonial status countries (with consequent increases in aspirations and roles in international affairs), international trade and labor systems, rapid technological growth in the past half century, and increased confidence in the potential of technology to contribute to the solution of development programs.

On the one hand, the issue of development may be perceived as arising from the fact that there are significant differences between the "industrialized" or "developed" countries (DC) and the "developing" or "lesser developed" countries.

On the other hand, however, it is also important to recognize the severity of the economic conditions of the LDCs themselves -- apart from any comparison with the DCs. These conditions both present a human problem of major dimensions and constitute a serious threat to the political and economic stability of these nation states (which in turn does have implications at the international level) -- not to mention implications for the social/cultural fabric of a society.

The development problem has been approached from a variety of perspectives and disciplines, each with its own weaknesses and limitations. In recent years the concept of Appropriate Technology has been receiving increased attention by those who are concerned with technology utilization in developing countries. The Appropriate Technology concept does take us a step in the right direction of recognizing the importance of the specific context relevant to development and the role of technology. However, we must recognize that the Appropriate Technology concept is itself a specific, particular type of approach which has significant limitations.

Thus, there remains an imperative need for the development of a comprehensive contextual analytical framework in order to avoid the mistakes that have occurred in past efforts to relate technology R&D, transfer and utilization to the development needs of developing countries -- mistakes which have resulted in accusations of economic exploitation, and domination of the LDCs. Many of these mistakes have resulted from inadequate analyses both of the situation in the LDC's and of the role that DC's can play in the process of development - - which in turn has been due to a lack of a comprehensive analytical framework that simultaneously is true to the existing reality and permits the generation of policy relevant information in this context. The CISST contextual analytical framework is well suited for in-depth contextual analysis of situations such as development (and of issues such as role of technology in development) which require consideration of a complex set of interactive factors and dynamics. Our contextual analytical framework provides a methodology which can be utilized by an agency to identify and evaluate policy/program level issues and options, as well as identifying areas where further research is needed.

The historical evolution and current issues of development and the current concerns indicate that the CISST contextual analytical framework would be applicable to the problem of development and thus would be relevant and useful to agencies concerned with such issues.