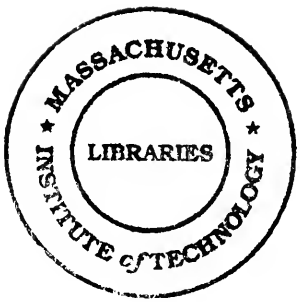
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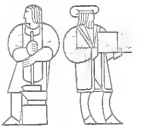

THE NEW INDUSTRIAL ENGINEERING: INFORMATION TECHNOLOGY AND BUSINESS PROCESS REDESIGN

Thomas H. Davenport
James E. Short

June 1990

CISR WP No. 213
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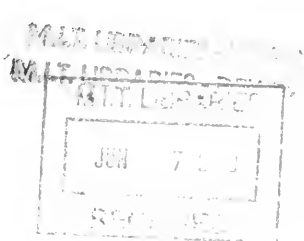

The New Industrial Engineering: Information Technology and Business Process Redesign

Thomas H. Davenport
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Abstract

At the turn of the century, Frederick Taylor revolutionized the design and improvement of work with his ideas on work organization, task decomposition and job measurement. Taylor's basic aim was to increase organizational productivity by applying to human labor the same engineering principles that had proven so successful in solving technical problems in the workplace. The same approaches that had transformed mechanical activity could also be used to structure jobs performed by people. Taylor, rising from worker to chief engineer at Midvale Iron Works, came to symbolize the ideas and practical realizations in industry that we now call industrial engineering (IE), or the scientific school of management[1]. In fact, though work design remains a contemporary IE concern, no subsequent concept or tool has rivaled the power of Taylor's mechanizing vision.

As we enter the 1990's, however, two newer tools of the "information age" are beginning to transform organizations to the degree that Taylorism did earlier. These are **information technology** — the capabilities offered by computers, software applications, and telecommunications — and **business process redesign** — the analysis and design of work flows and processes within an organization. The ideas and capabilities offered by these two tools working together have the potential to create a new type of industrial engineering, changing the way the discipline is practiced and the skills necessary to practice it.

This article explores in detail the relationship between information technology (IT) and business process redesign (BPR). We report on research conducted in nineteen companies, including detailed case studies from five firms engaged in substantial process redesign. After defining business processes in greater detail, we extract from the experiences of companies we studied a generic five-step approach to redesigning processes with IT. We then define the major types of processes, along with the primary role of IT in each type of process. Examples are provided throughout of specific efforts within these firms to use IT to radically redesign and upgrade particularly important business processes — some as part of a total business redesign, others as more isolated, but still valuable, efforts. Finally, management issues encountered at our research sites in using IT to redesign business processes are considered.

IT in Business Process Redesign

The importance of both information technology and business process redesign is well known to industrial engineers, albeit as largely separate tools for use in specific, limited environments.[2] IT is used in industrial engineering as an analysis and modelling tool, and IE's have often taken the lead in applying IT to manufacturing environments. Well-known examples of IT use in manufacturing include process modelling, production scheduling and control, materials management information systems, and logistics. Indeed, in most cases where IT has been used proactively to redesign work in a given firm, this redesign has most likely been in the manufacturing function, and industrial engineers are the most likely individuals to have carried it out.

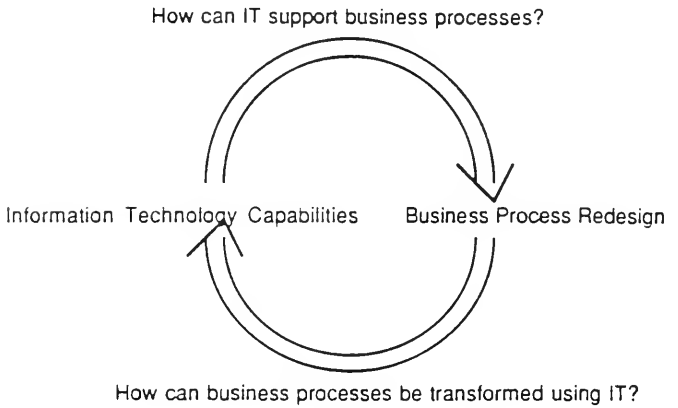
IE's have begun to analyze work activities in nonmanufacturing environments, but their penetration into offices has been far less than in factories. Many office work "innovations", such as shared stenography and typing pools, have come and gone. IT has certainly penetrated the office and services environments — in 1987 *Business Week* reported that almost 40% of U.S. capital spending went to information systems, some $97 billion a year — but IT has been used in most cases to hasten work rather than to transform it.[3] In fact, the discipline of systems analysis, as practiced by IT professionals in designing computer and telecommunications applications to meet business needs, draws heavily from the work decomposition approaches of Taylorism and scientific management. With few exceptions, IT's role in the redesign of nonmanufacturing work has been disappointing; few firms have achieved major productivity gains.[4] Aggregate productivity figures for the U.S. have shown no increase since 1973.[5]

Given the growing dominance of service industries and administrative functions in the Western economies, this type of work is as much in need of analysis and redesign as the manufacturing environments to which IT has already been applied. To accomplish this, many firms have found that a broader view of both IT and business activity, and of the relationships between them, is now necessary. IT should be viewed as more than an automating or mechanizing force; it can fundamentally reshape the way business is done. In short, business should be viewed as more than a collection of individual or even functional tasks; instead it should be broken into processes that can be designed for maximum effectiveness, in both manufacturing and service environments.

Our research also suggests that IT can also have a stronger role in business process redesign than that of useful tool. In leading edge practice, IT and BPR have a recursive relationship, as Figure 1 illustrates. Each is the key to thinking about the other. Thinking about information technology should be in terms of how it supports new or redesigned business processes, rather than business functions or other organizational entities. And thinking about business processes and process improvements should be in terms of the capabilities information

technology can provide. *We refer to this broadened, recursive view of IT and BPR as the new industrial engineering.*

Figure 1
The Recursive Relationship Between IT Capabilities and Business Process Redesign



Why Now?

Unlike Taylor's world at the turn of the century, businesses today face new competitive threats and uncertainties on a global scale. Companies face mounting pressures to improve strategic and operational performance in product development, product delivery, and customer service and management. In these areas firms strive to reduce cost and time to market, while simultaneously improving quality, service and risk management.[6]

Where Taylor could focus on workplace rationalization and individual task efficiency in confronting a largely stable business environment, today's corporations do not have the luxury of such environmental stability.[7] Individual tasks and jobs change faster than they can be redesigned. Responsibility for an outcome is spread over a group, rather than assigned to the single individual as in the past. Today, companies increasingly find it necessary to develop more flexible, team-oriented, coordinative and communication-based work capability. In short, rather than maximizing the performance of particular individuals or business functions, companies must maximize within and across entire organizations a set of interdependent activities designed to produce value for a customer. Such business processes are a new approach to coordinating among organizational entities, and information technology's promise — and perhaps its ultimate impact — is to be the most powerful tool in the 20th century for reducing the costs of this coordination.[8]

What Are Business Processes?

We define business processes as a set of logically-related tasks performed to achieve a defined business outcome. This is similar to Pall's definition of process as "the logical organization of people, materials, energy, equipment, and procedures into work activities designed to produce a specified end result (work product)." [9]

A set of processes form a business system — the way in which a business unit, or a collection of units, carries out its business. Processes have two important characteristics:

1. they have customers; that is, processes have defined business outcomes, and there are recipients of the outcomes. Customers may be either internal or external to the firm; and

2. they cross organizational boundaries; that is, normally the occur across or between organizational subunits. Processes are generally independent of formal organizational structure.

Common examples of processes meeting these criteria include:

- Developing a new product
- Ordering goods from a supplier
- Creating a marketing plan
- Processing and paying an insurance claim
- Writing a proposal for a government contract

The process of ordering goods from a supplier, for example, typically involves multiple organizations and functions. The eventual user of the goods, the purchasing department, and the supplier organization all are participants. The user could be viewed as the customer of the process. The process outcome could be either the creation of the order, or perhaps more usefully, the actual receipt of the goods by the user.

The examples of processes mentioned thus far have been large-scale, affecting whole organizations or groups. It is also possible to cite examples of more detailed processes that meet the definitional criteria above. These might include the process of installing a windshield in an automobile factory, or completing a monthly departmental expense report. IT-driven process redesign may also be desirable for these more detailed processes, though the implications of redesigning these detailed processes may be important only in the aggregate. In many of the firms we studied, analyzing processes in great detail was highly appropriate for some purposes, e.g., the detailed design of an information system or data model to support a specific work process. However, in the firms that were truly beginning to redesign the way their business functions, however, a broader view of processes was taken.

A Brief History of Process Thinking

Process thinking has become widespread over the past several years, due largely to the quality movement. Industrial engineers and others who wish to improve the quality of operations are urged to look at an entire process, rather than a particular task or business function.[10] At IBM, for example, "process management will be the principal IBM quality focus in the coming years."[11] But process discussions in the quality movement's literature rarely even mention information technology. Rather, the focus is usually on improving process control systems in a manufacturing context; when IT is discussed, it is in the context of factory floor automation. Recent IE literature also borders on process thinking when advocating cross-functional analysis,[12] although, as will be described below, cross-functional processes are only one possible type of process.

Other than the quality-oriented manufacturing process redesign many companies have undertaken, most processes in major corporations have not been subject to rigorous analysis and redesign. Indeed, many of our current processes result from a series of ad hoc decisions made by functional units, with little attention to efficiency and effectiveness across the entire process. Many processes have never even been measured. In one of the manufacturing companies we studied, for example, no one had ever analyzed the elapsed time from a customer's order to delivery. Each individual department involved in the product delivery process, such as sales, credit checking, and shipping, felt that it had optimized its own performance, but in fact the overall process was quite lengthy and unwieldy.

Even fewer business processes have been analyzed with the capabilities of IT in mind. Most business processes were developed before modern computers and communications even existed. When technology has been applied to processes, it is usually to automate and/or speed up isolated components of an existing process. This creates problems of communications within processes and impediments to process redesign and enhancement. For example, in a second manufacturing firm where we analyzed business processes, the procurement process involved a vendor database, a materials management planning system, and accounts payable and receivable systems, all separate and running on different hardware platforms with different data structures. Again, each organizational subunit within the process had developed and optimized its own IT application, but no one subunit had looked at (or had responsibility for) the process in its entirety. We believe the problems this firm experienced are very common in most businesses today.

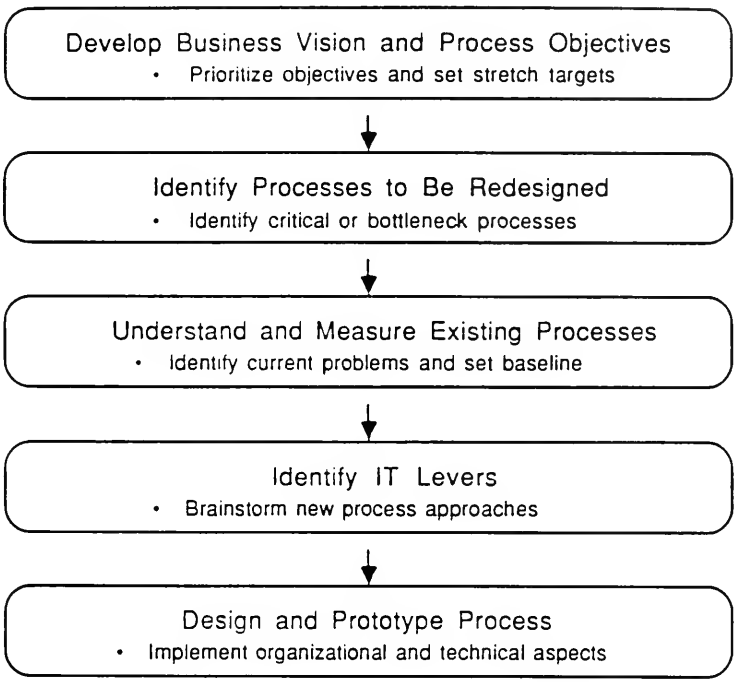
Redesigning Business Processes With IT: Five Steps

Our message thus far is that, based on our research findings, many organizations need to redesign key business processes around the capabilities offered by IT. We observed, however, that companies often struggle to effectively implement BPR. In this section, we outline a generic,

five step approach to redesigning processes with IT. We then define the major types of processes we encountered in our research, and describe the primary roles of IT in each type.

Assuming that a company has decided its processes are inefficient or ineffective, and therefore in need of redesign, how should it then proceed? This is a straightforward activity, but five major steps are involved: develop the business vision and process objectives, identify the processes to be redesigned, understand and measure the existing process, identify IT levers, and then the actual design and prototyping of the new process (See Figure 2). We observed most or all of these steps being performed in companies that were succeeding with BPR. Each step is described in greater detail below.

Figure 2
Five Steps in Process Redesign



Develop Business Vision and Process Objectives

When process redesign has been undertaken in the past, it was typically done with the objective of simply "rationalizing" the process, i.e., eliminating obvious bottlenecks and inefficiencies, without any particular business vision or context in mind. This was the approach of

the "work simplification" aspect of industrial engineering, an important legacy of Taylorism. An example of the rationalization approach is given in the following quote out of a 1961 "Reference Note on Work Simplification" from Harvard Business School:

> A good manager asks himself *why* things are done as they are, extending his inquiry to every aspect of the job and the surroundings in which it is performed, from the flow of paper work to the daily functioning of his subordinates...He is expected to supply the stimulus and show that job improvement or simplification of work is not only important but also is based on common-sense questioning aimed at uncovering the easiest, most economical way of performing a job.[13]

Our research suggests strongly that rationalization is not an end in itself, and is thus insufficient as a process redesign objective. Furthermore, rationalization of highly decomposed tasks may lead to a less efficient overall process. Instead of task rationalization, redesign of entire processes should be undertaken with a specific business vision and related process redesign objectives in mind.

In most of the successful redesign examples we analyzed, the company's senior management had developed a broad strategic vision into which the process redesign activity fit.[14] At Xerox, for example, this vision involved taking the perspective of the customer, and developing systems rather than standalone products, both resulting in the need for cross-functional integration. At Westinghouse, the vision consisted largely of improving product quality. Ford's well known vision involved adopting the best practices of Japanese automobile manufacturers, including those of Mazda, of which it is a partial owner.

Each of these visions resulted in specific objectives for process redesign. The most likely objectives for process redesign are the following:

- **Cost reduction** - this objective was implicit in the "rationalization" approach. Cost is an important redesign objective in combination with others, but insufficient in itself. Excessive attention to cost reduction results in tradeoffs that are usually unacceptable to process stakeholders. While optimizing on other objectives seems to bring costs into line, optimizing on cost does not bring about other objectives.

- **Time reduction** - Time reduction has been only a secondary objective of traditional industrial engineering. Increasing numbers of companies, however, are beginning to compete on the basis of time.[15] Processes, as we have defined them, are the ideal unit on which to focus time reduction analysis. One common approach to cutting time from a product design process is to make the steps in the process begin simultaneously, rather than

sequentially, using IT to coordinate design directions among the various functional participants. This approach has been taken, for example, in the design of computers, telephone equipment, automobiles, and copiers (by Digital Equipment, AT&T Bell Labs, Ford, and Xerox, respectively).

- **Output quality** - All processes have outputs, be they physical — such as in manufacturing a tangible product — or informational — such as in adding data to a customer file. Output quality has frequently been the focus of process improvement in manufacturing environments; it is just as important an objective in service industries, and in processes with only internal customers. The specific measure of output quality may be uniformity, variability, or freedom from defects; this should be defined by the customer of the process. For example, Bruns and McFarlan[16] have described how Otis Elevator redesigned its elevator service dispatching process around an information system, radically improving service quality and consistency.

- **Quality of work life (QWL)/learning/empowerment** - A frequently neglected objective of process redesign is the work life quality of the individuals carrying it out. IT can lead either to greater empowerment of individuals, or to greater control. Zuboff has pointed out that IT-intensive processes are often simply automated, and that the "informating" or learning potential of IT in processes is often ignored.[17] Moreover, Schein has pointed out that organizations often do not provide a supportive context for individuals to introduce or innovate with IT.[18] Of course, it is rarely possible to optimize all objectives simultaneously, and in most firms, the strongest pressures are to produce tangible benefits. Yet many of the managers in firms we studied believed in the value of learning and empowerment objectives, and were struggling to determine how to advance them.

Some firms have been able to achieve multiple objectives in redesigning processes with IT. American Express, for example, set out to improve the cost, time, and quality of its process for making credit authorization decisions by embedding the knowledge of its best authorizers in an "Authorizer's Assistant" expert system. This successful redesign led to a $7 million annual reduction in costs due to credit losses, a 25% reduction in the average time for each authorization, and a 30% reduction in improper credit denials. Hewlett Packard, in applying IT to the redesign of several key manufacturing processes, also found that it could improve cost, time, and quality simultaneously.

Finally, all firms found it important to be specific in setting objectives, even to the point of quantification. Though it is difficult to know how much improvement is possible in advance of a

redesign, "reach should exceed grasp". Setting goals that will stretch the organization will also provide inspiration and stimulate creative thinking. For example, a company might decide to reduce the time to bring new products to market by 80%, or reduce output errors from 12 per thousand to 1 per thousand. In the accounts payable process at Ford, the "stretch" goal was to eliminate invoices — to pay suppliers upon receipt of their products or services. This goal has since been achieved with the aid of an information system to confirm expected deliveries at the loading dock, and as a result, Ford has eliminated three quarters of the jobs in its accounts payable function.

Identifying Processes to Be Redesigned

Our research suggests that most organizations could benefit from IT-driven redesign of all their business processes. However, the amount of effort involved in process redesign, and in building IT solutions to support redesigned processes, places a practical limitation on total corporate redesign. Even when total redesign was the ultimate objective, the company selected a few specific processes for its initial redesign efforts. Moreover, when there was insufficient commitment to total redesign, a few successful examples of IT-enhanced processes were viewed as a powerful selling tool.

The means by which processes to be redesigned are identified and prioritized is one of the key issues in process redesign. This is often difficult because most managers do not think about their business operations in terms of processes. There are two major approaches to the issue. The first, which we label the "exhaustive" approach, attempts to rigorously identify all processes within an organization and then prioritize them in order of redesign urgency. The second, which we refer to as "high-impact", attempts to identify only the most important processes or those most in conflict with the business vision and process objectives, using a minimum of time and effort.

The exhaustive approach to process identification is often associated with the "information engineering" method of information system planning (developed by James Martin in the early 1980's), in which an organization's use of data dictates both processes to be redesigned, and the design outline for specific processes. Most information engineering projects, however, are not process-oriented.[19]

One specific information engineering method, employed at several divisions of Xerox in Europe and the U.S., involves identifying business activities and the data entities used by them in a large business activity by data entity matrix. The clusters of activity-entity interactions in the cells of the matrix are the major business processes of the organization. Xerox managers must then prioritize processes in the order for which new IT applications support would be provided. Although the process identification activity in some Xerox divisions took as little as three months, many organizations have found the information engineering approach to be very time consuming.

The alternative to the exhaustive approach is to focus quickly on high-impact processes. Most organizations have some idea of which business areas or processes are most crucial to their success, or those which are most "broken" or inconsistent with the business vision. If not, these processes could normally be identified in a few senior management workshops (a discussion of process types, such as that presented below, would be a useful topic in such a workshop), or through extensive interviewing. At IBM, the sales force was surveyed to determine the relative importance of multiple customer support processes; the generation of special bids was perceived as being of highest priority, and was the first process to be redesigned. Some of the business areas or problems identified as important may need to be further refined into processes.

Companies we studied that employed the high-impact approach generally found it sufficient. Those companies taking the exhaustive approach have not had the resources to quickly address all identified processes; why identify them if they cannot be addressed? As a rough "rule of thumb", most companies in our research were unable to redesign and support with IT more than ten to fifteen major processes per year (i.e., one to three per major business unit); there is simply not enough management attention to do more. Furthermore, some organizations have abandoned the exhaustive approach, as resources or time consumed became excessive.[20]

Whether the exhaustive or high-impact approach is used, companies have found it useful to classify each process to be redesigned in terms of beginning and end points, interfaces, and organization units (functions or departments) involved, including in particular the customer unit. A thorough view of a process will usually result in a broader scope than managers within the organization have previously taken. For example, a sales manager may be aware that there are inefficiencies in the customer order entry area. A skilled process consultant might decide that the whole process of negotiating, receiving, and fulfilling orders needs to be redesigned. Whether this broader view of the problem is broken down into three processes, or viewed as one, is not important; expanding the scope of the process analysis is the key issue.

High-impact processes should also have owners. In virtually all the cases of process redesign we analyzed, an important step was getting owners to buy-in to the idea of process redesign, and the scope of process analysis, at an early stage. In several companies, it was felt that the owner's job should be either above the level of the functions and units the process crosses, or, if on the same level, the owner should be willing to change the *status quo*. The difficulty with this, however, is that some processes only come together at the CEO level; in this situation, the CEO should designate a senior manager as owner and invest him or her with full change authority. Processes that are fully contained within a single function or department can normally be owned by the functional or departmental manager under which they are carried out.

Understanding and Measuring Existing Processes

Companies had two primary reasons for understanding and measuring existing processes before redesigning them. First, problems with existing processes needed to be understood so that they would not be repeated. Secondly, it was important to measure existing processes to set a baseline for future improvements. If the redesign objective was to cut time and expense out of a process, the time and cost consumed by the "untouched" process had to be accurately measured. Westinghouse Productivity and Quality Center consultants found that simply graphing the incremental cost and time consumed by the tasks of a process can often suggest initial areas for redesign. These graphs look like "step functions" showing the incremental contribution of each major task.

Understanding and measuring existing processes can easily be overemphasized, however. In several firms, the "stretch" goal in redesigning a process was less eliminating problems or bottlenecks, than in making radical improvements over the status quo. Designers should be working with a clean slate, though informed by past process problems and errors. Similarly, the process should not be measured for measurement's sake. Only the specific objectives that are the focus for redesign should be measured. As with the high-impact process identification approach, an "80-20" philosophy is usually appropriate.

Identifying IT Levers

In even the most sophisticated industrial engineering approach, IT capabilities were thought of only after a process had been designed. The conventional wisdom in IT usage has always been to first determine the business requirements of a function, process, or other business entity, and then develop a system. The problem with this approach is that an awareness of the capabilities IT brings to a process can — and should — influence its design. Knowing that product development teams can exchange computer aided designs over large distances, for example, might affect the structuring of a product development process. Consideration of the role of IT in a process must therefore be done in the early stages of its redesign.

In several firms, this was accomplished in brainstorming sessions, with the process redesign objectives and existing process measures in hand. It was also useful to have in hand a list of the generic capabilities of IT in improving business processes. In the broadest sense, all of IT's capabilities involve improving coordination and information access across organizational units, thereby allowing for more effective management of task interdependence. More specifically, however, Figure 3 illustrates eight critical IT capabilities and their organizational impacts.

Figure 3
IT Capabilities and Their Organizational Impacts

Capability	Organizational Impact/Benefit
Transactional	IT can transform unstructured processes into routinized transactions
Geographical	IT can transfer information with rapidity and ease across large distances, making processes independent of geography
Automational	IT can replace or reduce human labor in a process
Analytical	IT can bring to bear complex analytical methods on a process
Informational	IT can bring vast amounts of detailed information into a process
Sequential	IT can enable changes in the sequence of tasks in a process, often allowing multiple tasks to be worked on simultaneously
Knowledge Management	IT allows the capture and dissemination of knowledge and expertise to improve the process
Tracking	IT allows the detailed tracking of task status, inputs, and outputs
Disintermediation	IT can be used to directly connect two parties within a process that would otherwise communicate through an intermediary (internal or external)

There are undoubtedly other important IT capabilities that can reshape processes. Organizations may want to develop their own lists of capabilities that are specific to the types of processes they employ. The point is twofold: IT is so powerful a tool that it deserves its own step in process redesign, and IT can actually create process design options rather than simply supporting them.

Process Design and Prototyping

For most firms, the final step in this approach is to factor in all the above steps and design the process. This is usually done by the same team that performed the previous steps, getting input from process constituencies and using brainstorming workshops as the mode of operations. A key point is that the actual design is not the end of process redesign activities. Rather, the new design can be viewed as a prototype, with iteration expected and managed through successively better designs. Key factors and tactics to consider in process design and prototyping include the use of IT as a design tool, generic design criteria, and the use of organizational prototyping for implementing redesigned processes.

Designing a business process is largely a matter of diligence and creativity. Emerging IT technologies, however, are beginning to facilitate the "process" of process design. Some computer-aided systems engineering (CASE) products are primarily designed to draw process models. The ability to rapidly draw models and make changes as suggested by process owners will speed redesign and facilitate owner buy-in. Some CASE products can actually generate computer code for the information systems application that will support a modelled business process.

Several Xerox divisions, for example, are moving directly from process modelling to code generation for high-priority processes. They report improved productivity and high user satisfaction with the resulting systems. A further benefit is that when the business process changes, the IS organization can rapidly modify the affected system. In Xerox's case, the tool employed for this purpose was Texas Instruments' Information Engineering Facility, one of several major CASE products. Use of this product, and generally of any code generation product, presumes that process designers will use the "exhaustive" approach to process identification, as described above.

We observed several different design criteria that were used by companies in evaluating alternative designs. Most important, of course, is the likelihood that a design will satisfy the chosen design objectives. Others mentioned in interviews included the simplicity of the design, the lack of buffers or intermediaries, the degree of control by a single individual or department (the more concentrated the process control, the better), the balance of process resources, and the generalization of process tasks (so that they can be performed by multiple individuals).

Mutual Benefit Life's (MBL) redesign of its individual life insurance underwriting process illustrates a final, important point about process design. In the past, underwriting a life insurance policy was an assembly line process. At MBL, it involved 40 steps with over 100 people in 12 functional areas and 80 separate jobs. To streamline this lengthy and complex process, MBL undertook a pilot project with the goal of improving productivity by 40%. To integrate across the 12 functional areas, multiple jobs, and multiple employees involved, MBL created a new role, called Case Manager. This role was designed to centrally perform and coordinate all underwriting tasks, utilizing a workstation-based computer system capable of pulling data from all over the company. Upon experimenting with the new role and underwriting process, the firm learned that two additional roles were necessary on some underwriting cases: specialists, such as lawyers or medical directors, in knowledge-intensive fields, and clerical assistance, drawn from "pools" of typists, data entry personnel, and so forth. With the new role and redesigned process, senior managers at MBL are confident of reaching the 40% goal in a few months.

Mutual Benefit's new underwriting process, as well as IT support for it, was prototyped and subsequently modified. This example illustrates the value of creating organizational

prototypes, as well as IT application prototypes, in IT-driven process redesign. The concept of prototyping IT applications is rapidly gaining acceptance in the application development field. Advocates argue that prototyping an IT change is usually faster than conventional "life cycle" development in getting to the end result, and, more importantly, the end result is much more likely to satisfy the customer. There is considerable interest in extending prototyping to business process changes and organizational initiatives.[21] The implications of this extension are that process designs, after agreement by owners and stakeholders, would be implemented on a pilot basis (perhaps in parallel with existing processes), examined regularly for problems and objective achievement, and modified as necessary. As the process approached final acceptance, it would be phased into full implementation.

Defining Process Types

The five steps described above are sufficiently general to apply to most types of organizations and processes. Yet the specifics of redesign activities vary considerably by the type of process under examination. Different types of processes require different levels of management attention and ownership, need different forms of IT support, and have different business consequences when redesigned. In this section we present three different dimensions in which processes vary, and the resulting process types are described with examples.

Understanding and classifying the different types of processes is important because organizations can appear to managers as a seamless web of interconnected processes, no one entirely separate nor even definable without the others. Also, as we note above, few managers are familiar with process thinking; knowing about multiple process types helps managers to relate these processes to their own experience. With multiple process types in mind, a manager can begin to isolate particular processes for analysis and redesign, including activities which, without process thinking, might otherwise be overlooked.

There are three major dimensions that can be used to define processes (see Figure 4). These are the organizational entities or subunits involved in the process, the type of objects manipulated in the process, and the type of activities taking place in the process. Each dimension and resulting process type is described below, along with a discussion and examples of the role of IT.

Figure 4
Types of Processes

Process Dimension and Type	Typical Example	Typical IT Role
Entities		
Interorganizational	Order from a supplier	Lower transaction costs; eliminate intermediaries
Interfunctional	Develop a new product	Work across geography; greater simultaneity
Interindividual	Approve a bank loan	Role and task integration
Objects		
Physical	Manufacture a product	Increased outcome flexibility; process control
Informational	Create a proposal	Routinizing complex decisions
Activities		
Operational	Fill a customer order	Reduce time and costs; increase output quality
Managerial	Develop a budget	Improve analysis; increase participation

Defining Process Entities

Because processes take place between organizational entities, it is possible to classify them by the type of entities involved. Each type has different implications for IT benefits.

Interorganizational processes are those taking place between two or more different business organizations. Others have pointed out the increased emphasis on both intercompany relationships in the form of strategic alliances or value-adding partnerships[22] and the use of IT between organizations.[23] Johnson and Lawrence, for example, cite McKesson's Economost system for pharmacy distribution as the vehicle for establishing, and enhancing, the value-adding partnership between McKesson and its pharmacy customers. However, focusing on interorganizational processes and the role of IT in facilitating these processes (without necessarily changing the equity structure between firms) is a new emphasis.

Much of this work implicitly suggests that it is no longer possible to improve significantly internal business performance without redesigning interorganizational processes. This goes beyond our classical concern with controlling the environment. Increasingly, companies are concerned with coordinating activities that extend into the next (or previous) company along the value added chain (e.g., how your distributor sells your product to the end customer, or how your supplier numbers the components it sells to you). Several U.S. retail, apparel, and textile companies, (for example, Dillard's Department Stores, Haggar Apparel, and Burlington Industries) have linked their business processes to speed reordering of popular apparel fashions. When Dillard's inventory of a particular pants style falls below a specified level, Haggar is notified electronically. If Haggar does not have the cloth to manufacture the pants, Burlington Industries is notified electronically. As this example, called Quick Response, and other early adopters of electronic data interchange (EDI) illustrate, information technology is the major vehicle by which this interorganizational linkage is executed and enhanced.

For most companies, simple market relationships are the most common source of interorganizational processes. All the tasks involved in a selling/buying transaction form a critical process for sellers, and an increasingly important one for buyers seeking greater procurement quality, cost efficiency, and responsiveness. Yet much of the focus in improving market relationships through IT has been on a simple transaction level, rather than on an interorganizational business process level. Again, this is well illustrated by much of the EDI movement.

Buyers and sellers involved in most EDI have concentrated on speeding up routine purchasing transactions, such as invoices or bills of materials. Few companies implementing EDI have attempted to redesign the broader procurement process surrounding transaction automation — from the awareness that a product is needed, to the development of approved vendor lists, or even to the delivery and use of the purchased product. In the future, sellers will need to look at all buyer processes in which their products are involved.

Moreover, many firms will need to help the buyer improve those processes. DuPont's concept of "effectiveness in use" as the major criterion of customer satisfaction with a product is one example of a leading approach to measuring the effectiveness of interorganizational processes. DuPont is thus motivated not simply to sell a product, but to link its internal processes for creating and providing value to the product to its customers' processes for using the product. This concept led DuPont to be an early user of EDI-provided Material Safety Data Sheets, furnished along with the chemicals it sells to its customers to ensure their safe use.

At Westinghouse, an interorganizational process approach was used in dealing with Portland General Electric (PGE), a major customer of power generation equipment. Managers at PGE called upon Westinghouse's Productivity and Quality Center, a national leader in process

improvement, to help them implement EDI. The Center did have experience in EDI, but the team assigned to work with PGE asked if they could analyze the entire process by which it procured equipment from Westinghouse and other suppliers. The Westinghouse team found that while implementing EDI could yield efficiencies on the order of 10%, making major changes in the overall procurement process, including using EDI and bypassing the purchasing department altogether for most routine purchase orders, could lead to much greater savings. In one case, the time to execute a standard purchase order, for example, could be reduced from 15 days to half a day; the cost could be reduced from almost $90 to $10.

A second major type of business process is **interfunctional**. These processes are within (internal to) the organization, but cross several different functional or divisional units. Interfunctional processes should be viewed as task sets that achieve major operational objectives, such as new product realization, asset management, or production scheduling. They may also include important management processes, such as strategic planning, personnel development, or financial control. Customer service, product development, and product delivery are examples of major interfunctional processes. Most management processes, e.g., planning, budgeting, and human resource management, are also typically interfunctional.

In manufacturing, many companies found in their quality improvement programs that producing quality products and services required addressing difficult interfunctional issues. Yet most firms have never even listed their key interfunctional processes, let alone analyzed or redesigned them, with or without the aid of IT.

Two companies which recently have analyzed their key interfunctional business processes are Baxter Healthcare Corporation and US Sprint Communications Company. At Baxter, the firm's 1985 merger with American Hospital Supply provided the context for a major reanalysis of key business strategies, and the alignment of the IT infrastructure to those strategies.[24] As part of a seven month IT planning effort, the company defined 29 major interfunctional processes, and analyzed the current and future role of IT in supporting them. For example, in the distribution area, the company identified order entry, inventory, warehouse management, purchasing, transportation, and equipment tracking as key processes. The success of this IT planning effort led Baxter to incorporate the process definition approach into its annual corporate planning process.

At US Sprint, well-publicized problems with its customer billing system prompted the company's IT function to develop a strategic data model for the entire business as part of a comprehensive systems improvement program. This model defined the corporate data entities and key interfunctional processes necessary to run the business. Sprint is now involved in a major new phase of the program, assigning ownership to key processes, and continuing to identify improvements — and ways to measure them — in each process. The data model definition and

other activities in the systems improvement program raised the IT organization's composite internal quality index by more than 50% in one year.[25]

A major problem in redesigning interfunctional processes is that most information systems of the past were built to automate specific functional areas or parts of functions. Few third-party application software packages have been developed with support of a full business process in mind. However, organizations increasingly are realizing the need for interfunctional systems. Yet very few have modelled existing interfunctional processes or redesigned them, and companies will run into substantial problems in building interfunctional systems without such models.

Interindividual processes are those involving tasks within and across small work groups, typically within a function or department. Examples of such processes might include a commercial loan group approving a loan in a bank, or a flight crew preparing a flight for takeoff at an airline. This type of process has become more important as companies shift to self-managing teams as the lowest unit of organization. Information technology is increasingly capable of supporting interindividual processes; hardware and communications companies have developed new networking-oriented products, and software companies have begun to flesh out the concept of "groupware" (e.g., local area network-based mail, conferencing, and brainstorming tools).[26]

Several companies, including GM's Electronic Data Systems (EDS) and several other IT vendors, are actively exploring IT tools and group dynamics methodologies to facilitate the effectiveness of meetings and small group interactions. At EDS, the primary focus is on enhancing automobile product development (clearly an interfunctional process) through the IT-facilitated development teams. The company's Center for Machine Intelligence has developed a computer-supported meeting room, and is studying its implications for group decision making and cooperative work.[27]

Interindividual processes may be the most efficient type, because all tasks within the process (and perhaps even the customer of the process) are within a small group. As companies begin to acknowledge both the value of process thinking and the role of self-managing teams, interindividual processes will become more common. It should be pointed out, however, that IT can make possible the execution of processes within teams of employees who may be scattered around a country and even the world. As an example, Ford is renowned for its ability to create new car designs through teams whose members are both in Europe and in the U.S. Because Ford has standardized on computer-aided design systems, and created common data structures for the design process, engineers can share complex three-dimensional designs across the Atlantic. Similarly, a small team at Digital Equipment used the company's extensive electronic mail and conferencing capabilities to build the core of a new systems integration business. The team was scattered around numerous Digital facilities in the U.S. and Europe, and only rarely met in person.

Defining Process Objects

Processes can also be categorized by the types of objects manipulated by the process. The two primary object types are physical and informational. In physical object processes, real, tangible things are either created or manipulated; manufacturing is the obvious example. Informational object processes create or manipulate information. Processes for making a decision, preparing a marketing plan, or developing a new product design are examples of informational object processes.

Many processes involve the combination of both physical and informational objects. Indeed, adding information to a physical object as it moves through a process is a common way of adding value. Most logistical activities, for example, combine the movement of physical objects with the manipulation of information about their whereabouts. Success in the logistics industry is often dependent on the close integration of physical and informational outcomes in business processes; both UPS and Federal Express, for example, track package movement closely with computers and communications networks.

The potential for using IT to improve physical processes is well known. It allows greater flexibility and variety of outcomes, more precise control of the process itself, reductions in throughput time, and elimination of human labor. These benefits have been pursued for the past three decades in the form of computer integrated manufacturing, robotics, and other forms of factory-floor automation. Still, manufacturing process flows are often the result of historical circumstance, and should usually be redesigned before further automation is applied. This is particularly true in low volume, "job shop" manufacturing environments.[28] Redesigners of physical processes should also consider the role of IT in providing information to improve processes; Shoshana Zuboff has described this "informating" effect in detail for the paper industry.[29]

Strangely, the proportion of informational processes already transformed by IT is probably lower than that of physical processes. True, legions of clerks have become unemployed because of computers. But the majority of information processes to which IT has been applied are those involving high transaction volumes and low transaction complexity. Now that these have been conquered, the emphasis needs to shift to processes incorporating unstructured tasks and performed by high-skill knowledge workers. Relevant IT capabilities for these types of processes include the storage and retrieval of unstructured and multi-media information, the capturing and routinizing of decision logic, and the application of far-flung and complex data resources to a problem. A computer vendor's advertising videotape, for example, illustrates how artificial intelligence and "hypertext", or mixed-media databases, combine to lead a manager through the process of developing a budget for his department. The IT capabilities in the video are available today, but they are rarely applied to such information-intensive yet unstructured processes.

Defining Process Activities

The examples given thus far of typical business processes have involved two types of activities: operational and managerial. Operational processes are those involved in the day-to-day carrying out of the organization's basic business purpose, e.g., product development and production processes, and customer service processes. Managerial processes are those which help to control, plan, or provide resources for operational processes. Past uses of IT to improve processes, limited as they are, have been largely operational. We therefore will focus almost entirely on managerial processes in this section.[30]

It is not a new idea to apply IT to management *tasks*. For over twenty years, the potential of decision support systems, executive support systems, and other managerial productivity and information tools have been trumpeted. We believe, however, that the benefits have remained more potential than actual because of the absence of systematic process thinking. Few companies have rigorously analyzed managerial activities as processes subject to redesign. Even the notion of managerial activities involving defined outcomes (a central aspect of our definition of business processes) is somewhat foreign. How would such managerial processes as deciding on an acquisition or developing the agenda for the quarterly board meeting be improved if they were treated as processes — i.e., measured, brainstormed, and injected with IT capabilities?

The generic capabilities of IT for reshaping management processes include improving analytic accuracy, enabling broader management participation across wider geographical boundaries, generating feedback on actions taken (the managerial version of "informating" a process), and streamlining the time and resources a specific process consumes. Texas Instruments and Xerox's corporate headquarters provide excellent examples.

Texas Instruments has developed an expert system to facilitate the capital budgeting process. Managers in a fast-growing and capital-intensive TI division were concerned that the time and experience necessary to prepare capital budget request packages would become an obstacle to the division's growth. The packages were very complex, and few employees had the requisite knowledge to complete them accurately. The system was developed by two industrial engineers with expertise in both the technology and process.

For TI, the system has radically improved the capital budget request process. Capital request packages prepared with the system require far less time than the manual approach, and conform better to the company's guidelines. One employee experienced in capital requests reported a reduction in package preparation time from 9 hours to 40 minutes; of the first 50 packages prepared with the system, only three did not conform to guidelines, compared to an average of ten using a manual approach.[31]

While many firms have developed executive information systems (EIS) for their senior managers, at Xerox Corporation headquarters, IT has been used to improve a specific managerial

process, i.e., the review of division strategic plans. Prior to the development of the EIS, the planning process was somewhat haphazard; each division prepared its planning documents in a different format, and furnished different types of information to headquarters. Plans often came in too late for the corporate management committee to review them before the review meeting. An EIS was developed that included standard formats, specified information, and graphic templates for fast comprehension. Divisional plans were then created on executive workstations and delivered instantaneously over Xerox's network to all corporate management committee members. They can now read the plans beforehand and can move directly to decisions at the review meeting. The workstations are even used in the meeting itself, allowing revisions to be made and agreed upon before adjournment. As one manager put it, "...(the system) lets us communicate at higher speed and in greater depth."[32]

Management Issues in IT-Enabled Redesign

Following the identification and redesign of the firm's processes (using either the exhaustive or high impact approach), the firms we studied found that several key issues remained to be addressed, and would be of ongoing importance as they implemented process-oriented management. These issues included management roles in the redesign activity, organization structure implications, new skill requirements, creating a function to perform IT-enabled BPR, the proper direction for the IT infrastructure, and the need for continuous process improvement. We discuss each issue below.

Management Roles

Perhaps the greatest difficulty encountered by firms in bringing about IT-driven redesign is obtaining and keeping management commitment to the changes any redesign will bring. Because processes themselves cut across various parts of the organization, a process redesign effort driven by a single business function or unit will probably encounter resistance from other affected parts of the organization. Both high-level and broad support for change is necessary.

To perform the five redesign steps described above, several companies created a cross-functional task force headed by a senior executive. These task forces included representation from key staff and line groups likely to be affected by the changes, including the IT and Human Resources functions. It was particularly important that the customer of the process be represented on the team, even when the customer is external. The team composition was ideal when some members of the group had some record of process or operations innovation involving IT.

As the redesign teams selected processes for redesign and developed redesign objectives, they needed to work closely with the managers and staff of the affected units. Of course, getting process changes implemented is usually more difficult than determining what changes should be

made. Ideally, managing process change is similar to other types of change management, except that the cross-functional nature of process redesign increases the number of stakeholders, thereby increasing the complexity of the effort.

It was also important to have strong senior management commitment to the redesign effort, up to and including the CEO. It was necessary to make clear throughout the organization that redesign was necessary, that differences of opinion would be resolved in favor of the customer of a process, and that IT would play an important role. In many cases, the CEO also communicated any structural implications of the redesign effort to affected organizational units and staff (the implications of process redesign for structure are discussed in the next section).

An example of the importance of the CEO's role in process redesign is found at GUS Home Shopping, the largest home shopping company in Europe. GUS undertook a $90 million project to redesign its logistical processes with IT. The company's redesign objectives involved both cost and time: to be able to sell a product within 5 minutes of its arrival on the loading dock, and to be able to deliver a product to the customer's door at an average cost of 60 cents. In meeting these objectives, the company's Managing Director commented on his role:

> To change our business to the degree we have demands integration. How involved should the Managing Director get in designing computer systems? My view is totally, because he's the one who can integrate across the entire organization.[33]

Process Redesign and Organizational Structure

A second key issue is the relationship between process orientation and organizational structure. Certainly someone must be put in charge of implementing a process change, and then managing the redesigned process thereafter. But process responsibilities are likely to cut across existing functional and unit organizational structures. How can process organization and traditional functional organization be reconciled?

One possible solution is to create a new organizational structure along process lines, in effect abandoning altogether other structural dimensions, such as function, product, or geography. There are risks to this, however: as business needs change over time, new processes will be created that cut across the previous process-based organization. This does not mean that a process-based structure cannot be useful, but only that a specific process-based structure will have to be changed frequently to closely follow how business is done.

While no firm studied has converted wholly to a process-based structure, a few organizations have moved in this direction. For example, Apple Computer is beginning to incorporate a process orientation into its structure. Its CEO, John Sculley, describes the company as one of the few major corporations built after the Information Age began. Apple has recently moved away from a functional structure to what executives describe as an IT-oriented, process-

based, customer satisfaction-driven structure called "New Enterprise". The company relishes its lack of formal hierarchy; Apple managers describe their roles as highly diffuse, and team and project-based.

A more conservative approach would be to create a matrix of functional and process responsibilities. However, because of the cross-functional nature of most processes, the functional manager who should have responsibility for a given process is not always easily identified. The company may also wish to avoid traditional functional thinking in assigning process responsibilities. For example, it may be wiser to give responsibility for the process of supplies acquisition to a manager who uses those supplies (i.e., the customer of the process), rather than to the head of the purchasing function.

New Skill Requirements

For process management to succeed over the long run, managers will need to develop facilitation and influence skills. Again, when processes cut across organizational units, traditional sources of authority may be of little use in process change and improvement. Managers will often find themselves trying to change the behavior of employees who do not work for them. In these cases, they must learn to persuade rather than to instruct, to convince rather than to dictate. Of course, these recommendations for change in managerial behavior are consistent with many other organizational maxims of the past several years; they just happen to be useful in process management as well.[34]

Several organizations that are moving toward IT-driven process management are conducting formal programs for the development of facilitation skills. These programs encourage less reliance on hierarchy, more cross-functional communication and cooperation, and more decisionmaking by middle- and lower-level managers. Such a program at American Airlines, called "Committing to Leadership", is being used to build an organizational infrastructure at the same time a new IT infrastructure is being built. At Levi Strauss, which has heavily used IT to facilitate inter-organizational processes (including the "Quick Response" processes described above, the company is encouraging individual decisionmaking to enable horizontal communication and business processes.

An Ongoing Organization for Creating Process Change

Organizations that have redesigned key processes will also need to establish an ongoing organization to oversee continuing redesign and organizational "tuning", and to ensure that information systems support process flows. In most companies, the analytical skills needed for redesigning processes are most likely to be found in the IT function. However, individuals in the IT function will also require a high degree of interpersonal skills to be successful as the "new

industrial engineers". The ideal group would combine the responsibilities of multiple functional areas, e.g., information systems, industrial engineering, quality, process control, finance, and human resources.

There are a few emerging examples of such process change groups. Silicon Graphics has created a specific process consulting group for ongoing process management; it is headed by a director-level manager. On a project basis, Ford Motor increasingly combines IT function employees with industrial engineers to redesign key processes, as it did recently on a redesign of the parts warehousing process.

At United Parcel Service, the Industrial Engineering function, which includes more than 1500 IE's, is the traditional locus for process redesign. The UPS group is incorporating IT skills in the IE function at a rapid rate, and creating task forces with IT and IE representation for process redesign projects. Federal Express, its competitor, has gone even further, renaming its IE organization the "Strategic Integrated Systems Group", placing it within the Information Systems function, and giving it responsibility for designing and implementing major IT-driven business changes.

Process Redesign and the IT Organization

Just as IT is a powerful force in redesigning business processes, process thinking has important implications for the IT organization and the technology infrastructure it builds. Though few IT groups will have the power and influence to lead an IT-driven redesign, there are several important roles they can play. First of all, the IT group may need to play a behind-the-scenes advocacy role, convincing senior management of the power offered by IT and process redesign. Secondly, as demand builds for process redesign expertise, the IT group can begin to incorporate the IE-oriented skills of process measurement, analysis, and redesign, perhaps merging with the IE function if there is one in the company. It can also develop an approach or methodology for IT-enabled redesign, perhaps using the five steps described above as a starting point.

What must the information systems function do technologically to prepare for process redesign? IT professionals must recognize that they will have to build most systems needed to support (or enable) processes rather than buying them from software package vendors, because most application packages are designed with particular functions in mind. IT professionals will need to build robust technology platforms on which process-specific applications can be quickly constructed. This implies a standardized architecture with extensive communications capability between computing nodes, and the development of shared databases. However, like the organizational strategies for process management described above, these are appropriate technology strategies for most companies, whether or not they are redesigning processes with IT.

Continuous Process Improvement

It is also important that process improvement be continuous. The concept of process improvement, as developed in the quality movement, requires first that the existing process be stabilized. The performance of the process then becomes predictable, and its capabilities become accessible to analysis and improvement.[35] Continuous process improvement occurs when the cycle of stabilizing, assessing, and improving a given process becomes an institutional practice. The concept of continuous process improvement has received considerable attention in manufacturing, due largely to the impact of Toyota Motor Company's production and just-in-time inventory (*Kanban*) systems. A key element in *Kanban* is continuous improvement, or "*kaizen*" (a Japanese term meaning continuous improvement).

As in the Toyota example, IT-enabled business process redesign must generally be dynamic, constantly stressing process improvement through the application of IT. Those responsible for a process should constantly investigate whether new information technologies make possible new ways of carrying out a process. IT is continuing to evolve, and some forthcoming technologies will have substantial impact on the operational and management processes of the next decade.[36] The IT infrastructure, as discussed above, must be robust enough to enable continued increases in functionality for the applications that support a particular process.

Case Study: IT-Driven Process Redesign at Rank Xerox U.K.

Rank Xerox U.K. (RXUK), a national operating company of Xerox Corporation, has engaged in the most comprehensive IT-driven process redesign of any company we have studied. The changes at RXUK have been led by David O'Brien, the division's Managing Director, who arrived at the company in 1985. O'Brien quickly came to two realizations about RXUK's business: first, the company needed to focus on marketing "office systems" rather than its traditional reprographics products; and secondly, the company's strong functional culture and inefficient business processes would greatly inhibit its growth. He began to see his own organization as a test bed for using integrated office systems to support integrated business processes; if such a concept were successful, he could use RXUK as a model for customers.

The company began to redesign its business in 1987. In a series of offsite meetings, the RXUK senior management team reappraised its external environment and mission, and then identified the key business processes needed for the company to succeed in its mission. The group began to restructure the organization around cross-functional processes, identifying high-level objectives for each process and creating task forces to define information and other resource requirements for each process. They created career systems revolving around facilitation skills and cross-functional management, rather than hierarchical authority. O'Brien decided to keep a somewhat functional formal structure, because functional skills would still be needed in a process

organization, and because the level of organizational change might have been too great with a wholly new structure.

The level of change was still very high. Several senior managers departed because they could or would not manage in the new environment. Two new cross-functional senior positions, called "facilitating directors", were created, one for organizational and business development, the other for process management, information systems, and quality. O'Brien took great advantage of the "honeymoon" period accorded to new CEO's, but managing the change required heavy personal attention:

> Of course, this new thinking was in quite sharp contrast to some of the skills and attitudes of the company. We were introducing a change in management philosophy in a company which, in many ways was very skillful and effective, but in a different product-market environment. We faced all the issues of attitudinal change and retraining which any such change implies. We were moving to a much more integrated view of the world and had to encourage a major shift in many patterns of the existing culture. This meant a very hard, tough program of selling the new ideas within the organization as well as an extensive and personal effort to get the new messages and thinking to our potential customers.[37]

As the key processes were identified and their objectives determined, the company began to think about how information technology (its own and from other providers) could enable and support the processes. The Facilitating Director of processes and systems, Paul Chapman, decided that a new approach to developing information systems around processes was necessary. His organization identified the information engineering product discussed above as the only one consistent with a process orientation, and worked with an external consultant in using the system tools to refine and confirm the process identification. The output of the process identification consisted of 18 "macro" business processes (for example, logistics) and 145 different "micro" processes (e.g., fleet management).

The senior management team reconvened to prioritize the identified processes for system development, and identified seven macro processes as of particular importance: customer order life cycle, customer satisfaction, installed equipment management, integrated planning, logistics, financial management, and personnel management. The personnel management process was selected as the first for systems implementation, because it was viewed as relatively easy to attack, and because personnel systems were crucial in tracking the development of the new skills required by the company. The personnel system has now been successfully completed, using the automated code generation capabilities of the Information Engineering Facility product, in substantially less time than with normal methods.

RXUK's financial situation began to improve as it redesigned its business processes. The company emerged from a long period of stagnation into a period of 20% revenue growth. Jobs not

directly involved in contact with customers were reduced from 1100 to 800. Order delivery time was reduced from an average of 33 days to 6 days. Though many other factors in RXUK's markets were changing during this time, O'Brien credits the process redesign for much of the improvement.

Other Xerox divisions heard of RXUK's success with process redesign and began efforts of their own. Xerox's U.S. product development and marketing divisions have major cross-functional teams performing process redesign. Paul Chapman, RXUK's director of processes and systems, has been seconded to Xerox corporate headquarters, where he is heading a cross-functional team looking at corporate business processes. Commitment to IT-driven process redesign by Xerox senior corporate management is also growing.

Summary

We believe that the industrial engineers of the future, regardless of their formal title or the organizational unit that employs them, will focus increasingly on the redesign of business processes with IT. We have only begun to explore the implications and implementation of this concept, and only a few companies have ventured into the area. Many of the companies who have employed IT to redesign particular business processes have done so without any conscious approaches or philosophies such as those we have outlined here. In short, the actual experience base with IT-enabled process redesign is limited.

Yet managing by customer-driven processes that cross organizational boundaries is an intuitively appealing idea that has worked well in the companies that have experimented with it. And few would question that information technology is a powerful tool for reshaping business processes. The individuals and companies that can master the skill of redesigning processes around IT will be well-equipped to succeed in the new decade and millennium.

References

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1. L. Gulick, "Notes on the Theory of Organization," in L. Gulick and L. Urwick, eds., *Papers on the Science of Administration* (New York: Institute of Public Administration, 1937), p.9; F.B. Gilbreth, *Primer of Scientific Management* (New York: D. Van Nostrand Company, 1914).

2. S. Sakamoto, "Process Design Concept: A New Approach to IE," *Industrial Engineering* March 1989, p. 31.

3. "Office Automation: Making It Pay Off," *Business Week*, 12 October 1987, pp. 134-146. For an alternative perspective, see R.E. Kraut, Ed., *Technology and the Transformation of White-Collar Work* (Hillsdale, N.J.: Lawrence Erlbaum Associates, 1987).

4. G.W. Loveman, "An Assessment of the Productivity Impact of Information Technologies" (Cambridge, MA: MIT Sloan School of Management, Management in the 1990's, working paper 90s:88-054, July 1988). Loveman studied microeconomic data from manufacturing firms to estimate econometrically the productivity impact of IT in the late 1970's and early 1980's. In finding no significant positive productivity impact from IT, he argues that his findings in manufacturing raise serious questions about impacts in nonmanufacturing firms as well. Baily *et. al.* (1988) studied white-collar productivity and IT as one part of a broader inquiry into poor productivity growth. They found no evidence of significant productivity gain. See M.N. Baily and A. Chakrabarti, *Innovation and the Productivity Crisis* (Washington, D.C.: Brookings Institution, 1988).

5. Loveman (1988); Baily *et. al.* (1988). See also S.S. Roach, "America's Productivity Dilemma: A Profile of the Information Economy," Special Economic Study, Morgan Stanley & Co., April 1987.

6. J.F. Rockart and J.E. Short, "IT in the 1990's: Managing Organizational Interdependence," *Sloan Management Review*, Winter 1989, pp. 7-17.

7. Robert Horton, who became chairman and chief executive of British Petroleum in March, 1990, argues that his major concern in setting BP's course in the next decade is "managing surprise." Horton's belief is that the external business environment is so unpredictable that surprise, rather than managed change, is inevitable. See R. Horton, "Future Challenges to Management," *MIT Management* (Winter 1989), pp. 3-6.

8. T. Malone, "What is Coordination Theory?" (Cambridge, MA: MIT Sloan School of Management, Center for Information Systems Research, working paper no. 182, February 1988); K. Crowston and T. Malone, "Information Technology and Work Organization," (Cambridge, MA: MIT Sloan School of Management, Center for Information Systems Research, working paper no. 165, December 1987).

9. G.A. Pall, *Quality Process Management* (Englewood Cliffs, NJ: Prentice-Hall, 1987). Our structurally-oriented definition also complements that of Schein, who focuses on human processes in organizations — e.g., building and maintaining groups, group problem solving and decision making, leading and influencing, and intergroup processes.

See E.H. Schein, *Process Consultation: Its Role in Organization Development*, Volume I, Second Edition (Reading, MA: Addison-Wesley, 1988).

10. For example, see H.S. Gitlow and S.S. Gitlow, *The Deming Guide to Quality and Competitive Position* (Englewood Cliffs, NJ: Prentice-Hall, 1987) Chapter 5.

11. E.J. Kane, "IBM's Total Quality Improvement System," unpublished manuscript, IBM Corporation, Purchase, NY; p. 5; also G.A. Pall, 1987.

12. See, for example, M.F. Morris and G.W. Vining, "The IE's future role in improving knowledge worker productivity," *Industrial Engineering* July 1987, p. 28.

13. "Reference Note on Work Simplification", (Boston, MA: Harvard Business School, 1961) HBS Case Services #9-609-060.

14. The relationship between business vision and IT has been explored by several researchers under the auspices of the MIT Sloan School's five year "Management in the 1990s" research program. An overview volume is scheduled for publication by Oxford University Press in June 1990.

15. See, for example, G. Stalk, Jr., "Time — The Next Source of Strategic Advantage," *Harvard Business Review*, July-August 1988, pp. 41-51.

16. W.J. Bruns, Jr., and F.W. McFarlan, "Information Technology Puts Power in Control Systems", *Harvard Business Review* , Sept.-Oct. 1987, pp. 89-94.

17. S. Zuboff, *In the Age of the Smart Machine* (New York: Basic Books, 1988).

18. E.H. Schein, "Innovative Cultures and Organizations" (Cambridge, MA: MIT Sloan School of Management, Management in the 1990's, working paper 90s:88-064, November 1988).

19. Similarly, it would be possible to employ the information engineering approach to redesign specific processes that were selected because of their impact, rather than through information engineering. Information engineering and other redesign approaches based on data modeling are necessarily limited in scope. More than data is exchanged in many process relationships.

20. D. Goodhue, J. Quillard, J. Rockart, "Managing the Data Resource: A Contingency Perspective" (Cambridge, MA: MIT Sloan School of Management, Center for Information Systems Research, working paper no. 150, January 1987).

21. Dorothy Leonard-Barton introduced the concept of organizational prototyping with regard to the implementation of new information technologies. See D. Leonard-Barton, "The Case for Integrative Innovation: An Expert System at Digital," *Sloan Management Review*, Fall 1987, pp. 7-19.

22. R. Johnson and P.R. Lawrence, "Beyond Vertical Integration — The Rise of the Value-Adding Partnership," *Harvard Business Review*, July-August 1988, pp. 94-101.

23. J.I. Cash and B.R. Konsynski, "IS Redraws Competitive Boundaries," *Harvard Business Review*, March-April 1985, pp. 134 - 142. See also N. Venkatraman, "IT-Induced Business Reconfiguration: The New Strategic Management Challenge," paper presented at the annual conference of the MIT Center for Information Systems Research, June 1989.

24. T.J. Main and J.E. Short, "Managing the Merger: Building Partnership Through IT Planning at the New Baxter," *Management Information Systems Quarterly*, December 1989, pp. 469-486.

25. C.R. Hall, M.E. Friesen, and J.E. Short, "The Turnaround at U.S. Sprint: The Role of Improved Partnership Between Business and Information Management," in progress.

26. R.R. Johansen, *Groupware: Computer Support for Business Teams* (New York: The Free Press, 1988). Also see C.V. Bullen and R.R. Johansen, "Groupware: A Key to Managing Business Teams?" (Cambridge, MA: MIT Sloan School of Management, Center for Information Systems Research, working paper no. 169, May 1988).

27. See Harvard Business School case study, "The Center for Machine Intelligence: Computer Support for Cooperative Work," Lynda M. Applegate, 1988 (revised 1989).

28. J.E. Ashton and F.X. Cook, "Time to Reform Job Shop Manufacturing," *Harvard Business Review*, March-April 89, pp. 106-111.

29. See cases on "Tiger Creek", "Piney Wood", and "Cedar Bluff" in S. Zuboff (1988); other industries discussed by Zuboff primarily involve informational processes.

30. One might consider managerial processes synonymous with informational processes. Certainly the vast majority of managerial processes, such as budgeting, planning, and human resource development, involve informational objects. Yet it is important to remember that informational processes can be either operational or managerial, so we believe that this separate dimension of process types is warranted.

31. A case study describes the process and the creation of the expert system. See "Texas Instruments Capital Investment Expert System," Harvard Business School, 1988.

32. Some aspects of this process improvement are described in a Harvard Business School case study, "Xerox Corporation: Executive Support Systems," Lynda M. Applegate and Charles S. Osborne, 1988 (revised 1989).

33. R.H.C. Pugh, address to McKinsey & Co. information technology practice leaders, June 1989, Munich, Germany.

34. See, for example, A.R. Cohen and D.L. Bradford, "Influence Without Authority: The Use of Alliances, Reciprocity, and Exchange to Accomplish Work," *Organizational Dynamics*, Winter 1989, pp. 4-17.

35. See G.A. Pall (1987). See also M.A. Cusamuno, *The Japanese Automobile Industry* (Cambridge, MA: Council on East Asian Studies, Harvard University, 1985).

36. L.M. Applegate, J.I. Cash, and D.Q. Mills, "Information Technology and Tomorrow's Manager," *Harvard Business Review*, November-December 1988, pp. 128-136.

37. David O'Brien, quoted in "Rank Xerox U.K., Office Systems Strategy (C): Developing the Systems Strategy," case study from Henley - The Management College, September 1988. Other Rank Xerox U.K. information comes from personal interviews.

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