DESIGNING, MANAGING, AND IMPROVING OPERATIONS

DAVID M. UPTON

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David M. Upton

Harvard Business School

Prentice Hall, Upper Saddle River, New Jersey 07458

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Preface

The course described in this book has a number of antecedents at the Harvard Business School (HBS). In the mid-1960s, Wickham Skinner at the Harvard Business School became troubled by the increasingly common view among senior executives that manufacturing had become a deadweight in American industry, in spite of its rich history as the original source of much of the nation's economic power. Skinner saw the prospect of a lengthy and damaging decline in manufacturing in the United States. In response to the growing view that the problem of production had been "solved" and that manufacturing was an unnecessary activity in an advanced nation, Skinner set about swimming against the tide. He developed a framework that showed not only why manufacturing was so often seen only as a source of problems, but also how it could become a competitive strength.[1] His work laid the foundation for the concept of a Manufacturing Strategy. The bases of his argument were that (a) companies, even those in the same industry, compete in different ways, (b) that different operations systems had different characteristics and tradeoffs, and (c) that a company was therefore unlikely to succeed by simply adopting the same industry-standard operations system as its competitors. Skinner concluded that the manufacturing task was to mold the manufacturing resource—through a series of interrelated choices—to match the competitive strategy that the firm was pursuing.

With this work as a foundation, Hayes and Wheelwright,[2] and later Hayes, Wheelwright and Clark[3] pursued Skinner's idea of manufacturing as a competitive weapon[4] still further. The key to strengthening the power of that weapon, in their view, lay in the development and renewal of distinctive operating capabilities. To do this, companies needed to build operations that relentlessly pursued customer value and that saw continual learning and improvement as a central part of their task. The dominant source of operational capabilities was the plant itself rather than central corporate staff, and the primary determinant of those capabilities was the effectiveness of the operations manager. Empirical research supported this view, showing large differences in the effectiveness of operations managers across plants in the same industry and even within the same company. These findings alluded to the enormous potential that existed for well-trained operations managers to make a difference to the overall competitiveness of the company. The course on which this book is based was designed to help graduating students make such a difference.

At HBS, the most notable predecessor of this course was "The Operating Manager," launched by Skinner in the mid-seventies. Earl Sasser and Steve Wheelwright each developed material for the course, which broadened its scope over time to include sales functions and service organizations. In 1980, Bob Hayes created a new course, "The Management of Operations" (MOPS), which sought to help students understand the issues associated with operations at all levels in an organization. It achieved this using a model that

[1]Skinner, C. W. (1969). "Manufacturing—Missing Link in Corporate Strategy." *Harvard Business Review* May-June.

[2]Hayes, R. H. and S. C. Wheelwright (1984). *Restoring Our Competitive Edge: Competing through Manufacturing.* John Wiley and Sons, New York.

[3]Hayes, R. H., S. C. Wheelwright and K. B. Clark (1988). *Dynamic Manufacturing: Creating the Learning Organization.* The Free Press, New York.

[4]Skinner, C. W. (1985). *Manufacturing: The Formidable Competitive Weapon.* John Wiley and Sons, New York.

resembled peeling and re-assembling an onion: first, the issues, challenges, constraints and performance evaluation of a first-level supervisor were examined; next came the viewpoint of the department manager, then the plant manager and finally, the vice-president of operations. At a time when most manufacturing companies were relatively stable and hierarchical, this was a powerful pedagogical structure. About two-thirds of the way through the course, students were challenged to develop practical action plans for improving various dimensions of operating performance, such as productivity or defect rates, using the insights they had developed in the first part of the course. They would move back down the various levels to see how each was impacted by their plans for action. In 1985, after being developed further by Kim Clark and David Garvin, the course was split into two parts.

Garvin saw that the field of Operations Strategy had grown in importance to the point where it warranted a course of its own, and set about developing some of the material from MOPS as well as fresh material and new frameworks to build a new and successful course.[5] Meanwhile, the MOPS course progressively focused more and more on shop floor human resource issues. With the incorporation of much of its material into the first-year MBA course, it slowly dwindled.

During this time, Hayes, Pisano and Upton[6] developed a new Operations Strategy course. This course focused less on Skinner's initial model that matched operations decisions to a comparatively stable set of competitive priorities, and more on the dynamic development of operating capabilities in response to changing competitive requirements. Operations Strategy provided important insight about how the development and exploitation of operating capabilities can build lasting competitive advantage, but many of the decisions informed by the course were deliberately aimed at a comparatively high level in the organization.

In the 1990s more and more students were becoming interested in operations and manufacturing as a first job, either as line/staff managers or consultants, and many returned to talk about their experiences in those functions. In addition, the Harvard Business School was running a summer executive course (Building Competitive Advantage through Operations) that focused on the managers responsible for service and manufacturing operations. The issues they were dealing with were not simply a subset of the issues addressed by Operations Strategy. It became apparent that, to be effective, managers still needed the kind of practical knowledge that the original MOPS provided. Even MOPS, however, would not have addressed many of their concerns.

There were two principal reasons for this. First, the explosion in the application of information technology (IT) in operations often left students without an understanding of IT at a severe disadvantage. Knowing that IT needed to be used strategically in an operation was no substitute for knowing how to select computer hardware and software, how to build systems that would not be obsolete as soon as they were installed, and how to forge the power of information systems into the heart of the operation. Second, the torrent of operations improvement techniques and philosophies—re-engineering, lean production, agile manufacturing, mass customization, and total quality management to name a few—often left managers not knowing where to begin as they sought to improve their operations. Methods for operations improvement, it seemed, were almost randomly applied. The particular combination of methods employed could result from a persuasive consultant, the latest improvement fashion, or the philosophy to which higher levels of the organization subscribed. It became clear that our focus on the power of strategic capabilities in operations had deflected attention from the management of the very source of many of those operating capabilities: the individual operating unit. Designing, Managing, and Improving Operations (DMIO) was developed to address some of these issues.

DMIO explores the management of the individual operating unit, concentrating on the design of improvement paths that allow that unit to become a source of lasting competitive advantage, either in its own right, or as part of a larger network. The book is based on the premise that young operations managers can have a significant impact on

[5]Garvin, D. A. (1992). *Operations Strategy: Text and Cases.* Prentice-Hall, Englewood Cliffs, NJ.

[6]Hayes, R. H., G. P. Pisano and D. M. Upton (1996). *Strategic Operations: Competing through Capabilities.* Free Press, New York.

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the effectiveness, improvement rate, and competitiveness of their organization if they have the tools, knowledge, and inspiration to do so.

ACKNOWLEDGMENTS

A large number of people have contributed to this course over the past four years, many of whom are unaware of the importance of their contributions. They include managers, colleagues, and—most of all—the Designing, Managing, and Improving Operations (DMIO) students who have tested the material in its various incarnations.

My thanks go to Bob Hayes, Gary Pisano, Kim Clark, Uday Karmarkar, Steve Wheelwright, David Garvin, Bob Kaplan, Jonathan West, Helen Han, Roger Bohn, Dorothy Leonard, Jai Jaikumar, and Kent Bowen for their material and the ideas they have contributed over the years. Bob and Gary, in particular, spurred me to develop many of the ideas in DMIO when we worked together on our previous coursebook. Part of this course, as you will see, spans from both operations and information technology. Warren McFarlan and Kim Clark have both been important sounding boards for the concepts developed in this part of the course. At other schools, Gary Scudder at Vanderbilt, Morris Cohen at Wharton, and John Ettlie at the University of Michigan have been important contributors and "testers." Their viewpoints have been critical in ensuring a balanced book.

Andrew McAfee, a doctoral student at the Harvard Business School, has been a primary contributor to both the course and the book. Andrew's combined knowledge of both operations management and information technology is rare, and this book embodies much of his own work in the field. He has read countless drafts, attended the course religiously, contributed much of the material and has tested out teaching plans.

Christine Steinman, also a doctoral student at HBS, helped write many of the cases and teaching notes and has been both creative and patient as the various drafts were developed. Susan Rogers has also been an important aid, not least by helping to implement some of the ideas concerning information technology developed in DMIO at the Harvard Business School.

Thanks finally to Daniele Levine who assembled the artwork and to Sally Markham, my assistant. The experiment to cure her anglophilia by assigning her to work with me may now have succeeded.

David Upton
Boston, Massachusetts
April, 1997

Introduction

Over the past decade, operations management has changed in some fundamental and exciting ways. First, the old view of operations management as the task of running and maintaining a comparatively static production or service facility has given way to one characterized by a need for renewed flexibility, relentless improvement, and the development of new capabilities at the operating unit level. As the global curtain draws back to expose more, and more kinds of, operations to the mounting pressures of worldwide competition, there are fewer places for laggard operations to hide. The *context* in which the operations manager now works has changed to one that emphasizes *improving* an operation over simply *administering* it.

Second, as a result of this changing environment, the *skills* required of operations managers have begun to change. The tools of control are now overshadowed by the tools of operations improvement. The ability to involve a workforce as a central part of creating new capabilities has become more important than the ability to *control* them as part of a static process. There are also few operations today in which information technology (IT) does not play a central role. Operations managers now require an intimate understanding of IT and how to mold it into an operation to build superior performance and new ways of competing.

Third, the *scope* of the operating manager's job is broadening. Progressive waves of "rightsizing" and more plants that must compete directly on the open market rather than as protected feeder-plants in larger networks now mean that the unit manager must often be a strategist for the plant while still acting as the steward of its diverse community, building a deep understanding of how the operation and its technology work, and developing an improvement path to keep it ahead of its competition.

As compensation for these new challenges, the power of operations to create competitive advantage is now becoming broadly understood. Operations is seldom now seen as the "tail on the dog," whose job is simply to avoid messing up too badly. In a growing number of companies, operations has become an equal partner whose potential to create difficult-to-imitate and competitively significant capabilities is appreciated and exploited.

This course provides the tools, conceptual frameworks, and technological understanding necessary to manage operations in this increasingly challenging world.

FOCUS

Designing, Managing, and Improving Operations (DMIO) is aimed at students who intend either to manage or consult for operations in the manufacturing and service industries. While many of the cases are informative for senior managers, the primary objective is to prepare more junior operations managers and consultants to take effective action early in their careers, primarily in their first five years after graduation. A substantial part of the book is devoted to exploring issues at the intersection of Information Systems and Operations Management. While DMIO was designed for MBA students, much of the material is useful for students in industrial and manufacturing engineering, as well as students of operations-based information technology.

The focus of the book is primarily on the individual operating unit, in both manufacturing and services. The cases are biased towards action and implementation, but nevertheless rest on a common, conceptual premise: that striving to create a "world-class" operation is not enough to guarantee

long-term success. Even "continuous improvement" is insufficient if competitors are improving more rapidly, on more important dimensions of performance, over a longer period of time. DMIO stresses that the key to success lies in *designing* operations to provide a foundation for subsequent improvement, *managing* them in a way that directs, fuels and sustains that improvement path, and *improving* the operating unit with an explicit and effective strategy. Traditional courses in operations management have typically focused on one or the other of these activities. DMIO aims to integrate them.

It does this at three, ascending levels of analysis, which constitute the three modules of the course. These, again, have traditionally been considered in separate advanced courses.[1] Module 1 addresses the design, management and improvement of the fundamental building blocks of operations: operations *processes*. Module 2 looks at the *systems* used to coordinate processes, focusing on the use and management of information technology as part of such systems. Module 3 addresses the *operating unit* as a whole and looks at how the various processes and systems are designed and managed within a human community in a way the builds superior and rapidly improving performance. This final module also introduces the concept of an improvement strategy, which integrates the themes of improvement that run through the previous modules. The overarching message of the course is: operations must be designed for improvement, and that improvement must itself be designed.

CONTENT AND STRUCTURE

DMIO is organized into thirty sessions. Approximately 40% of the cases are non-US based. Many of the cases concern protagonists who are comparatively young, addressing the kinds of issues likely to be faced by operations managers early on in their careers.

The course is divided into three modules, which are described in detail in the associated overviews:

- Module 1: Designing, Managing and Improving Operations Processes
- Module 2: Operations Systems and Information Technology
- Module 3: Designing and Implementing Operations Improvement Strategies

The following provides an outline of the modules, as well as some of the driving issues in each of them.

MODULE 1: DESIGNING, MANAGING, AND IMPROVING OPERATIONS PROCESSES

The first module of the course looks at the mechanisms by which the performance of operations processes can be improved. It introduces the competitive importance of rapid process improvement, and shows how operations managers make a difference to the rate of that improvement. The module begins by considering processes designed for single products or services, then turns to multi-product processes and the management of flexibility.

A key concept in this module is that actions taken to change and improve existing processes fall into four progressive categories: *repositioning*, *exploration*, *reconfiguration*, and *radical redesign*. It looks at cases in which each of these levels of action are used and explores how these various process improvement actions combine to build an ongoing path for process improvement. The latter part of the module focuses on the issue of process

[1]See, for example, at the process level, DeGarmo (1997) or Schey (1987). At the systems level, the courses described by Vollman et al. (1997) and Hopp and Spearman (1996) examine coordinative issues. More recently, the course described by Cohen and Apte (1997) explores new technologies associated with manufacturing systems. Klein (1990) provides a case-based course focused at the operating unit (plant) level.

DeGarmo, E. P., R. A. Kohser and J. T. Black (1997). *Materials and Processes in Manufacturing.* Prentice Hall, Englewood Cliffs, NJ.

Schey, J. A. (1987). *Introduction to Manufacturing Processes.* McGraw Hill, New York.

Vollman, T. E., W. L. Berry and D. C. Whybark (1997). *Manufacturing Planning and Control Systems.* Irwin/McGraw-Hill, New York.

Hopp, W. J. and M. L. Spearman (1996). *Factory Physics: Foundations of Operations Management.* Irwin, Chicago.

Cohen, M. A. and U. M. Apte (1997). *Manufacturing Automation.* Irwin, Chicago.

Klein, J. A. (1990). *Revitalizing Manufacturing: Text and Cases.* Irwin, Chicago.

flexibility. It looks at the multi-faceted nature of flexibility, and provides a framework that allows managers to identify precisely the kind of flexibility required by a process or operation, and the action they can take to develop it.

This first module develops some important principles for the rest of the course. First is the idea that the design of a process or system affects its subsequent improvement, and that specific characteristics of a design facilitate or inhibit improvement over time. Second is how incremental improvement can be managed to build knowledge that provides a foundation for more radical change. Finally, it introduces the practical challenges of implementing improvement as an operations manager. Even though there might be a clear best "technical" answer for how the performance of a process should be improved, the approach needs to be shaped to fit the competitive situation of the operation and the human community in which it exists.

Driving Questions in Module 1

- What actions should managers take to foster rapid and ongoing process improvement?
- How should managers balance the need for a stable process with the need to improve it?
- How can manufacturing-based process improvement techniques be applied to service industries? What special considerations are there when doing so?
- How should one respond to a process crash, in which output and quality deteriorate dramatically?
- How should an operation learn about a process and how to improve it over time? How can knowledge be transferred between processes and across generations of processes?
- What is a "flexible" process? What kinds of flexibility are there, and how should one select among them? What mechanisms can be used to develop the various forms of flexibility?

MODULE 2: OPERATIONS SYSTEMS AND INFORMATION TECHNOLOGY

The second module of the course looks at the integration of processes into *systems*. Its focus is primarily on the role of information technology (IT) in building operations systems, rather than the more traditional systems-level issues such as production control and scheduling. This module is important for two reasons. First, it explores an important set of technologies that often appear difficult and unfamiliar. Second, it proposes a radically different approach to the management of those technologies in operations.

The fundamental question posed in the module is: "Can the principles of continuous improvement developed in the first module be applied to Information Systems?" The short answer, in general, is "not very easily". Operations managers frequently cite information technology as the source of their biggest headaches. Part of the reason is that the architecture of the systems, and the principles on which they are designed, constrain their subsequent improvement. Information systems tend to be "installed" in operations (often by "experts"), rather than built progressively as part of an overall improvement path. Cost and time overruns are common, and very often the system delivered is no longer suitable or adaptable to a changed competitive environment.

This module introduces the concept of a *dynamic architecture* for information systems, and explores principles that facilitate the change and improvement of information systems over time. It distinguishes between two very different approaches to information systems management. One focuses on the management of installation projects, while the other relies on the ongoing management and stewardship of a constantly changing system. This latter "path-based" approach demands much more ongoing attention and expertise on the part of the operations managers; but its rewards are increased flexibility, much greater potential for improvement, and an information system that can be shaped as part of the operation to build new forms of competitive advantage.

The module is designed with two additional goals in mind. As well as the broader conceptual ideas outlined above, and in more detail in the module overview, it also aims to teach what the technologies are and how they are used, based on the premise that it is not possible to manage a technology at this level without knowing what it is and what it does. The module begins at the lowest levels of the operation, looking at the role of information technology in process automation. It progressively moves up in level, looking at systems

for shop-floor coordination, MRP (Manufacturing Resource Planning) systems, and ERP (Enterprise Resource Planning) systems such as SAP's R/3. Finally, it looks at the use of information systems to connect operations to the outside world, and explores the management of systems for inter-plant coordination and connection with customers and suppliers.

Driving Questions in Module 2

- Why do so many operations spend large sums of money on IT and realize no apparent benefit?
- Why have so many fully-automated, "lights-out" operations been failures?
- How should an operations manager introduce information technology that automates tasks and possibly eliminates jobs?
- How should a manager address a situation in which the operation develops an information technology that is valuable externally? How should she decide whether to sell it?
- What is the value of computer integration? By what mechanisms does it deliver that value?
- How should the transition from push to pull-based manufacturing be managed?
- Why have Enterprise Resource Planning (ERP) systems been adopted so widely and so quickly by large organizations? What are the advantages and pitfalls of their use? Why are they proving so difficult and costly to implement?
- What is an open system? What considerations should be made when choosing between open and closed technologies and systems?
- When should information technology be shaped to fit an improvement path, and when should an improvement path be built around a particular information technology?

MODULE 3: DESIGNING AND IMPLEMENTING OPERATIONS IMPROVEMENT STRATEGIES

Having explored the improvement of processes and systems, Module 3 looks at the management and improvement of the operating unit as a whole. This integrative module uses many of the ideas and approaches seen in earlier classes to examine the challenges of designing and managing the improvement path of the operating unit. This third module develops the idea of an improvement strategy for an operating unit, that integrates the processes within an operation, the systems that control and coordinate it, and the community in which they exist.

The fundamental premise of this module is that there is no "one right way" to improve, just as there is no single way to compete. There are, however, some common decisions that need to be made. Together, this set of decisions characterizes the improvement strategy for the operating unit. Designing an improvement strategy includes such activities as setting a direction for improvement (rather than trying to improve on all performance dimensions at once). It means deciding which parts of the operation to focus on, whether at the level of basic processes, systems used for coordination within the plant, or the links with outside the operation. It involves selecting from the range of tools and methodologies for operations improvement. It means organizing the various subprojects, deciding which people should be involved, who will lead them, and how the projects will be phased over time. Finally, it requires careful consideration of how the operation will learn from the experience of others, and how it will capture the learning it generates to fuel future improvement.

While there is no one right way to improve, some improvement strategies are certainly better than others. A number of the cases in this book describe operations whose improvement paths have been ineffective or have become difficult to sustain. These cases allude to some common principles that inform the design of an operations improvement strategy. First, the improvement strategy should support the competitive mission of the firm. It should aim to develop capabilities that increase the performance of the operation on competitively valuable dimensions. While this might seem obvious, it is surprisingly often forgotten, as a number of the cases show. In the scramble to implement world-class practices or technology, the question "how will this improvement path help us compete?" is commonly unasked.

Second, the improvement path should fit the operations strategy of the company. It should consider, for example, the role of the plant in the broader network, the nature and history of the

workforce at the plant, the kind of process technology employed, the sourcing arrangements used, and how these factors work in concert to excel on the chosen competitive dimensions. This is important because managers will often change and "improve" one facet of their operation yet compromise a strength in another area, or be detrimental to how the operations system works as a whole. In addition, improvement in one area often requires a change in another part of the overall operations strategy to have any beneficial effect.

Third, the improvement strategy should be coherent, in the sense that each of its elements should fit together and complement one another. The tools and methods selected, for example, should be appropriate to the desired improvement goals. Finally, the improvement strategy should be efficient and deliver results over an appropriate timeframe: Will it achieve the desired improvement in performance quickly enough (and without Herculean effort)? Will the outcome be worth the resources that are required?

The latter part of this module looks at the challenges of implementing and sustaining operations improvement in a range of environments—for example, in developing countries, in mature, stagnant plants, and in operations that are already improving rapidly and effectively. A number of the implementation cases address the problem of an operations manager being the "person in the middle" who often has to deal with torn loyalties—between the plant in which he works every day and the needs of the corporation as a whole. It also explores how outsiders, such as consultants and customers can foster performance improvement. Finally, as a result of their improvement activities, operations will often generate unintended new capabilities; the last two sessions look at whether and how to exploit the new capabilities of an operating unit.

Driving Questions in Module 3

- How does a manager translate higher-level directives into an actionable strategy for the local operation?
- What are the keys to the successful management of operations crises (such as a chemical spill)?
- If I take charge of a low-performing operation, how do I decide what to tackle first?
- How should I keep an operations improvement initiative from burning out or backsliding? Why do some initiatives fizzle out while others provide the foundation for ongoing performance improvement?
- What are the key decisions that need to be made when developing an improvement strategy for an operating unit?
- How should the operations manager address the tensions that often arise as she tries to balance the demands from above (such as the corporate parent) with those from below (plant personnel)? What kinds of conflict arise, and how can they be resolved?
- What are the practical considerations of "empowerment?" How much authority should operators have over the jobs they do?
- What particular challenges are faced when managing a plant in an unfamiliar country?

THEMES

The themes developed in each part of the book are described in the associated overviews. There are, however, some important themes that run across modules, and bind the course together as a whole.

1. An Integrated View of Operations

Operations can be viewed at three highly interdependent levels. At the lowest level, an operating unit or plant is a collection of machinery and buildings. These physical investments combine with labor and materials to build *processes* that change the form of material and information, in a way to add value for customers. At the next level, an operation is an orchestra of *systems* and routines, which coordinate processes and marshal the flow of work, resources and knowledge in the operation. At a third level, an operation is a community of people. It can have all manner of processes, routines and systems, yet if a sense of common purpose and *community* is absent, it can fail to improve and flounder against competitors. Effective operations managers are constantly balancing these different levels as they manage the operations they lead, and strive to develop principles that integrate them. Managers with technical educations will often focus too heavily on first two levels. Others emphasize "the people side" of

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operations, in the absence of a technical understanding of how the operation works, and more importantly how it *might* work in the future. The dangers of these biases are illustrated by a number of cases in the book.[2]

Leading the community formed by an operation is one of the operations manager's most important roles. While the technical challenges of operations management have increased, so have the human ones. Plants increasingly comprise a diverse community of people with a wide range of educational backgrounds: People with graduate degrees will frequently work side-by-side those who may not have a high-school education. Managing operations in international environments brings the additional challenges of a different dominant language and culture. Formal, stable, organizational forms have become less common, being replaced with more fluid structures that can be a source of great stress as well as opportunity for those working in them. Aligning such communities around common objectives is difficult: The range of motivations and aspirations is broad. While incentive systems can play an important role, there are still large numbers of people for whom pride in a craft or sense of community overwhelm any financial incentives that might be constructed.

Throughout the course, the challenge is to integrate understanding of these levels at which operations are managed. This means integrating knowledge of the operation's financial circumstances, with a technical and strategic understanding of the operation's role and a social understanding of the community in which it exists. Cases are drawn from a range of social contexts to provide a broad-based exploration of these issues: an aging Midwestern plant with a dispirited workforce; an angry, strike-prone Korean plant; a proud high-technology plant in the Caribbean; and a struggling joint venture in mainland China. These cases stress that an understanding of systems and processes alone is never sufficient to guide effective operations improvement. An effective improvement strategy is founded on a deep understanding of the community and people that will make it work.

[2]For example, the *Cybertech* case illustrates the hazards of a processes/systems bias, while the *Corning Z-Glass* case describes a manager who has become ineffective because of an overconcentration on "his people", and his lack of understanding of the technology of process improvement.

2. Designing Operations for Improvement

While the importance of an integrated view of operations management runs throughout the course, one fundamental question dominates the first two modules: "How should an operation be *designed for improvement*"? This theme concerns what appears to be a set of fairly detailed matters related to process design and selection. However, this practical theme is the manifestation of a much broader conceptual issue: that the role of the operations manager is no longer simply to be a caretaker of installed equipment and processes, but is instead to build new operational capabilities through a process of experimentation and invention. Many engineers and information-systems specialists, however, are still working under the assumptions of the former model. The processes and systems they build are designed to be administered rather than improved. This can have a significant detrimental effect on the operation's ability to generate new capabilities over time. While technical specialists may develop a particular piece of equipment or part of a process, the *overall* design of an operation is within the control of the operations manager. She is responsible for the periodic selection and development of new equipment and processes, and decides how they fit together to build a functional whole. In carrying out these tasks, she is also a designer. The potential for ongoing improvement needs to be a primary criterion in developing that design.

Processes and systems that are designed to work flawlessly as soon as they are installed or commissioned can often, paradoxically, be the most difficult to improve. There are a number of reasons for this. The engineers who design a process often aim to optimize the performance of their design *at the time it is designed.* This is not an unreasonable objective, but it has some profound consequences for the operation's improvement path. First, engineers will often view process modularity (or the ability to change some elements of the process without significant impact on others) as secondary to the goal of short-term optimization. This may constrain the ability to make subse-

quent changes in parts of the process to mold it progressively to match changing requirements. Second, the last few percentage points of yield or microns of precision frequently demand the addition of considerable technical complexity. This can mean that the only people capable of changing a process significantly are the original vendors, or a select group of people within the operation. Finally, engineers will often see the line workers who operate the process as a hazard to its immediate functionality rather than as a potential source of long-term improvement. They will therefore design a process to lock out as much human intervention as possible, partly to avoid unnecessary work on the operators' part, but also to avoid having inexperienced operators (which all are at the outset) upset the way the process works.

Although this approach makes some sense in the short term, in the longer term, circumstances change. The process may need to be adapted for another purpose, and there may be powerful ongoing learning opportunities that derive from operators interacting with the equipment. The operators may even invent ways of using it that the engineers had not anticipated. In reality, this happens all the time. Managers can reflect the imperative for ongoing improvement by selecting equipment and processes whose designs facilitate their subsequent improvement and change. Fortunately, there are some specific principles that can be applied to make it much easier to build the potential for ongoing improvement into processes, systems, and whole operations. The course explores these principles in all three modules.

3. Developing Operations Improvement Strategies

The "design for improvement" theme concerns the creation of the *potential* for improvement and change rather than the improvement itself. If only this theme was emphasized, one might be left with the notion that all that is needed for competitive success through operations is then random 'continuous improvement' until the operation reaches 'world-class.' This is far from the truth.

The idea of world-class operations has been helpful to a large number of mediocre operations: The concept has provided them with a sense of what is achievable and has introduced many effective operations practices ("best practices") to ailing plants and service operations. At its heart, however, "world-class" characterizes a replicative, lagging strategy. First, as Hayes and Pisano[3] point out, it does not address a fundamental question: What should the operation be world class *at*? A fundamental tenet of Skinner's work[4] is that different operations exist to address different competitive needs, even within an industry. "World-class" denies the fundamental trade-offs that exist between, say, flexibility and cost, or responsiveness and degree of customization. It implies that an operation can have it all, and need not configure itself for a primary competitive role.

Second, it suggests that—to be effective—all one needs to do is adopt the operations practices of a group of key leaders in the field. But "world-class" does not address invention and innovation in operations. Innovation in operations means more than developing new products or processes: it means inventing new practices that go beyond the industry norms at many levels. Australian Paper Manufacturers[5] (APM), for example, a firm in the packaging business, saw its business in brown-bag papers evaporate and so needed to look for new uses for its papermaking expertise. To do so, it transformed its existing paper machines to make high-quality fine paper (primarily Xerox paper), and completely reinvented the way paper was made and delivered in the Australian market. It built new methods of scheduling its paper machines, allowing customers to "book time" on the machine to make exactly the kind of paper that they needed. This kind of innovation allowed it, over a period of three years, to attack the incumbent's existing 75% market share until, in 1993, the incumbent's holding company capitulated, and sold its remaining paper-making assets to APM at a steep discount. APM's goal was not mere parity; its assault was fundamentally a process of invention,

[3]Hayes, R. H. and G. P. Pisano (1994). "Beyond World-Class: The New Manufacturing Strategy." *Harvard Business Review* (January-February, 1994) 77–86.

[4]Skinner, C. W. (1969). "Manufacturing—Missing Link in Corporate Strategy." *Harvard Business Review* (May-June), Skinner, C. W. (1978). *Manufacturing in the Corporate Strategy.* John Wiley and Sons, New York.

[5]Upton, D. M. and J. Margolis (1991), *Australian Paper Manufacturers (A).* HBS Case (9–691–041).

and of using operations-based innovation to fuel competitive success.

Finally, bundled with *world-class* is often the idea of world-class *improvement* practices as well as world-class operating practices. With a panoply of such improvement methods available in the operations arena, managers are often hard-pressed to select between them. For example, the recent tide of reengineering and ISO 9000 initiatives has set many operations on a much more productive and appropriate improvement path than they might otherwise have followed. For others, however, they have been expensive and ill-conceived distractions serving, at best, to improve operations on unimportant dimensions of performance while diverting attention from other more valuable and appropriate improvement paths. The solution is to apply Skinner's basic idea that different operations need to do different things, but now in the dynamic sense: Operations must design an improvement path that is appropriate for the operation. Throughout the course, choices must be made between various improvement paths for the operating units. The idea of an improvement strategy for the operating unit is introduced, which provides a framework for developing an actionable improvement path that fits the competitive strategy of the company, meshes well with its operations strategy, and provides a coherent and effective basis for the development of new operating capabilities.

4. Managing Information Technology as an Integral Part of the Operation

The volume of information required to run modern operations has exploded so dramatically that operations without effective information systems are at a severe disadvantage. The information needed to build a Boeing 747 airplane, for example, would fill the aircraft it describes many times over if printed onto paper. In addition, manufacturers are following the lead of many service companies by combining information systems with their operations expertise to build new competitive weapons. This has brought new challenges and new opportunities. But only with sufficient knowledge of the technology and how to harness it as part of an operation is it possible to take advantage of those opportunities. To address this need, General Electric has begun an aggressive program to build IT literacy in operations. This initiative has already begun to pay off. New innovations in Web-based purchasing, for example, have cut GE Lighting's average purchasing lead time in half (to seven days) while cutting costs by 15%.[6]

In addition to playing an increasingly central role in operations management, the *nature* of the information technologies employed is also changing dramatically and more rapidly than ever before. Client-server architectures are now commonplace, and over the next five years, operations managers will begin to see broad intranet and even internet connectivity on the shop-floor itself. In GE Lighting's case, electronic blueprints are now posted electronically directly from the factory floor by this mechanism, to ensure that suppliers know exactly what current requirements are. Open systems, which facilitate rapidly built "mix-and-match" architectures, allow best-of-breed technologies to be brought together to build systems that are closely tailored to the operation's prevailing needs. While these modular systems allow for ongoing change as part of their design, they demand greater vigilance and stewardship on the part of the operations manager. Without careful, well-informed, and ongoing attention, such architectures can degenerate rapidly into the polyglot mish-mash of systems that have paralyzed so many operations in the past.

The problem of "design for short-term optimality" described earlier is especially severe in IT-based systems. The complexity of modern information systems and the typical operations manager's scant knowledge of the field mean that the IT "problem" is often handed wholesale to a software vendor or consultant. The systems they develop are usually completed late, over budget and match requirements that may have existed when the project was launched, but no longer prevail. This "installation" world-view can leave operations managers watching helplessly as the performance of their systems subsequently falls behind that of competitors. Their lack of knowledge about their IT resources, combined with the complexity and architectural constraints of the systems, precludes improvement without replacement. Their only solution is to leap to install an entirely new system.

[6]Wilder, C. and M. McGee (1997), *GE: The Net Pays Off.* Information Week, January 27, 1997.

A better solution is for operations managers to take more responsibility for their IT systems by designing and managing the *path* that IT investments place an operation on, rather than periodically looking for the next replacement system to solve the problem. This means answering questions like "how easy will it be to adapt this system to new requirements?" and "by what mechanisms will we improve it over time?"

This book views the management of information technology as an essential and central part of the operations manager's job, rather than an ancillary activity. It explores how information technology can be used to strengthen or change an operation's primary competitive objectives, and looks at the primary decisions that must be made to build an effective path for the development of IT as a part of an operation. It also introduces a new concept in the management of information technology for operations: the idea of a *dynamic architecture,* which allows the operations manager to mold information systems to the changing requirements of the operation over time.

Designing, Managing, and Improving Operations

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