

MANAGEMENT OF TECHNOLOGY

**The Key to Competitiveness
and Wealth Creation**

Tarek Khalil

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THE KEY TO COMPETITIVENESS
AND WEALTH CREATION

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PREFACE

Technology has always been intertwined with society's progress but never before in history has technology been so visibly linked to improvements in standards of living. The human aspiration for a better life increasingly depends upon technology and its effects on all aspects of life. Because of technology, our world is developing at a phenomenal speed. Technology's pace and scope of change are having profound effects on every human institution.

The enhancement of economic prosperity for countries, industries, and businesses depends upon the effective management of technology. Technology creates wealth. The proper exploitation of technology strongly influences business competitiveness, which is no longer a matter of choice but a matter of survival in the marketplace. At the macro and micro levels, nations and individual firms and organizations are acknowledging the link between innovation and economic success. The development of technology provides an innovator with a leading edge. Clearly, the application of technology, not just its development, is a key to success in the competitive global economy.

Factors that have been associated with improvement in technological competitiveness include long-term planning horizons, research, innovation, quality of products and services, productivity, free trade, and regulatory and social factors. Scholars have been debating the relative importance of these factors for years, and the debate is expected to continue. One factor of undeniable value is the education and training of human resources needed for the ever-changing technological organization. Leading authorities in technology, business, and government recognize that technology can flow across organizational boundaries as well as across borders of countries. Production facilities can also be moved from one location to another in search of the optimal combination of resources. It is people's knowledge and managerial skills that will continue to be the most valuable resource for the success of organizations. The success of organizations is increasingly dependent upon their leaders' ability to properly manage resources in a world of rapidly changing technology. Business enterprises must also be able to compete in a dynamic global market. Engineers, managers, scientists, and policy makers should be aware of the issues associated with the management of technology (MOT). The economic present and future of their businesses, as well as their countries, will depend on it.

This book has evolved from my ten years of teaching MOT, and it responds to engineering and business schools' demand for a textbook that would introduce MOT in their curricula. The book's objectives are:

- 1 To stress technology's crucial role in creating wealth and achieving competitiveness.
- 2 To introduce the main factors leading to the competitiveness of manufacturing and service enterprises in an increasingly global marketplace.
- 3 To emphasize the importance of considering both the speed and the scope of change in technological development and the consequential paradigm shift in the industrial and business enterprise system.
- 4 To emphasize the importance of integrating technology planning and business planning.
- 5 To introduce the process of technological innovation.
- 6 To present the concepts of technology and product life cycles.
- 7 To examine the challenges in managing the product life cycle from concept to market.
- 8 To stress the importance of research and development management, technology transfer, organizational structures, project management, and third-party influence in achieving and maintaining a competitive edge.
- 9 To explore human, social, and environmental concerns associated with technological change.
- 10 To link all concepts to the goal of industrial/business development for economic growth and the creation of wealth.

Although many of us have been educators of technology for many years, it was not until the late 1970s and early 1980s that we realized the need for education in MOT. The apparent loss of competitive advantage by many traditionally dominant American industries during that time period heightened the need for education in MOT. The research conducted by U.S. scientists and the technology created by the nation's engineers were still dominant, yet the American competitive advantage in the marketplace declined. Japan and Germany reemerged as economic powers, and several Asian countries became fierce industrial competitors. American industry had a rude awakening to the global competition in technology and markets and was forced to change its business paradigms. Academic institutions have attempted to respond by introducing courses, as well as new programs, in MOT, through either their engineering or their business schools. The material presented in this book is based on the courses that I teach in both the industrial engineering department and the interdisciplinary M.S. program in management of technology, jointly sponsored by the College of Engineering and the School of Business Administration.

The book's fifteen chapters constitute the major components of MOT:

- Chapter 1 introduces the definition of technology and its fundamental role in the development of society. It is important to start with a complete understanding of what we mean by "technology" in the context of an MOT course. I have observed, over the many years that I worked as an engineer involved in technology, and as I taught this

course, that even people working in the technology arena have difficulty defining technology or appreciating its impact. This chapter clarifies what we mean by technology and its associated terms. It also introduces the framework for MOT as an interdisciplinary field combining science, engineering, and business administration.

- Chapter 2 introduces the basis for the MOT field and asserts that it is not only technology but the management of technology that creates wealth. The chapter also briefly reviews the evolution of product and production technology over the past century.

- Chapter 3 presents the critical factors in managing technology, with emphasis on the changing environmental conditions in the world.

- Chapter 4 discusses the new paradigms of business. It examines changes in the external environment of business, organizational structure, project management, and human resource development and utilization.

- Chapter 5 introduces the principles of life cycles, including the technology life cycle, the product life cycle, and the market response at various phases.

- Chapter 6 discusses the process of technological innovation and the role of entrepreneurs, and it analyzes the factors contributing to successful innovations in the British Midlands and in Silicon Valley.

- Chapter 7 explores the issues of competitiveness on the global and corporate levels, summarizes data published on U.S. economic performance over the past two decades, and delineates important factors and policies that must be addressed to improve competitive positions at the national (macro) and firm (micro) levels.

- Chapter 8 presents fundamental concepts in strategizing and introduces methodologies used in strategic analysis and decision making. It outlines the concepts of strategic technology management, and it presents the elements of business strategy and technology strategy and stresses the importance of linking the two.

- Chapter 9 discusses technology planning.

- Chapter 10 explores methods of acquiring and exploiting technology, including the R&D mechanism of technology creation. It links the notions of creativity and innovation and discusses technology and human concerns.

- Chapter 11 focuses on technology transfer and its channels of flow across boundaries of countries and industries.

- Chapter 12 introduces and discusses technology management issues in creating world-class manufacturing and service organizations. It stresses the importance of the service sector in the economy.

- Chapter 13 presents traditional contemporary methods of organizational design. It analyzes the problems of the traditional vertical organization and introduces the concept of the horizontal organization. It points out the need for organizations to adjust their structures in order to harness the fruits of the technology revolution and avoid the pitfalls that may hinder their competitive positions.

- Chapter 14 briefly reviews management practices in the twentieth century. It explores the concept of organization reengineering, which became a buzzword for restructuring companies in the 1980s and 1990s.

- Chapter 15, "How America Does It," gives case studies of successful corporations that manage technology to remain competitive. It presents important lessons

from the experiences of some of the most admired corporations and managers. It draws heavily on the high-tech companies of the PC industry to illustrate many of the concepts discussed throughout the book. Lessons are extracted on the basis of real case studies.

The project of writing this textbook has been a challenging one. I wanted to provide comprehensive coverage of as many aspects of technology management as one can put in a book of manageable size for students taking an introductory or survey course. I did not want a handbook. However, I wanted to cover enough topics in sufficient detail for each to stand alone. Topics had to be presented in a concise and clear manner.

Many of the topics covered in this text have the potential of being expanded into a full course with a separate textbook. In fact, at the University of Miami we offer a 12-course master's program in management of technology. Each course is a three-credit-hour semester course. These courses delve into rigorous details of some of the subjects discussed in this book. However, the objective of this text is to tie these subjects together and show how all of them relate to one core and contribute to a main objective. The book concentrates on combining topics traditionally discussed either in engineering or in business administration curricula. It demonstrates the diversity and interdisciplinary nature of the issues associated with technology management. Yet the core objective is creation of wealth for nations, industries, and individuals.

Several relevant and important topics are mentioned only briefly in this text for the sake of completeness. These include general management, the role of capital, managing people, technology protection, third-party influence on technological change, information technology, finance, marketing, diffusion, and effects of technology on the environment. It is felt that specific details of these topics are better dealt with in specialized courses than in a survey course on management of technology.

Management of technology is a very dynamic subject. It is crucial for managing in a changing world environment. Technology is continuously progressing, and world markets are continuously shifting. The success or failure of organizations depends on the organizations' ability to ride the wave of change and still emerge as winners. In this text, several case studies are used to illustrate important concepts. Any example used will probably be dated, for tomorrow will bring a change in world conditions. I have elected to focus on classical case studies of companies that are recognized by most readers. I have extracted fundamental lessons to be learned from these cases that have withstood the test of time. Thus they can be applied, with appropriate modifications, in a generic way to other cases.

This book is an excellent textbook for introductory or survey courses in technology management. It is also suitable for an advanced undergraduate or graduate course. It is recommended for advanced courses if supplemented by additional readings of recently published journal articles, conference proceedings, and case studies. Additional readings and references are given at the end of each chapter from which supplemental material can be drawn. The material presented here has been successfully tested with both university students and mature professional audiences.

This textbook reviews the history and socio-political-economic implications and philosophical importance of technology as a means of creating economic wealth, as

well as its importance in ensuring competitiveness in the global economy. The book is valuable reading for government science and technology planners and forecasters, public policy makers, and macro- as well as microeconomic advisors to such individuals.

It is also of value to CEOs and directors of industrial corporations, government officials, investors and businesspeople, entrepreneurs and small-business owners, engineers, managers at all levels, and university faculty involved in technology and business education.

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