MANAGING TECHNOLOGY-BASED PROJECTS

Tools, Techniques, People and Business Processes

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Preface

Project management has evolved into a powerful system, used by virtually every enterprise to advance its business and to gain competitive advantage. Although project management has been practiced for thousands of years, only during the past few decades have we begun to understand what drives project performance and what can be done to link the project management system with the enterprise and its business strategy. Yet, on the operational side, many organizations have reached a maturity level that facilitates predictable execution of highly complex projects. Success is no longer random. It is driven by carefully designed and continuously improved project management systems and skill sets that pay attention to both the work process and the human side of project management.

This book focuses on technology-intensive business environments. However today, technology is everywhere, and it is difficult to find a business not affected by technology. Yet, some organizations are more intensely immersed in technology, either to produce new products or to use technology to execute their projects effectively, such as financial or medical services. Managers in these technology-intensive project environments perceive their managerial roles more challenging because of higher levels of dynamics, complexities, and uncertainties that exist in their projects, in comparison to environments less exposed to technology. Many of their technology-based projects require innovative solutions, collaboration with partners and contractor organizations, and expectations by senior management to align the project with the business objectives of the enterprise. Of course, all of this must be accomplished within the defined schedule, budget, and quality constraints. Lots of challenges!

Time after time, managers have told me that the biggest challenge they face is not so much in dealing with the technical issues of applying technology or working out technical solutions but in dealing with the dynamics and uncertainties associated with the complexities of the technology-based work environment, plus adding value to the enterprise. This requires specialized skills in planning, organizing, and guiding multidisciplinary activities. It also requires a great deal of people skills in building cross-functional teams and leading them toward desired results. This involves effective motivation, power and resource sharing, communications both vertically and horizontally, and conflict management. To get results, project managers must be social

architects who understand the culture and value system of the enterprise, and who can relate socially as well as technically. The days of managers who get by with only technical expertise or pure administrative skills are gone.

This book is written from the technology manager's perspective, for managers and professionals who must function effectively in complex, technology-oriented business environments. However, as technology crosses virtually all levels and all disciplines of an enterprise, the principles of managing in technology not only are relevant for science, engineering, and R&D but also apply to any organization and business that must effectively deal with the application, integration, and transfer of technology. Financial institutions, hospitals, law enforcement, government services, and media businesses are just a few examples of the vast array of organizations, outside the traditional engineering-scientific community, that see themselves in a high-technology enterprise.

In addition to serving as a professional reference, this book is designed as a text for college courses in project management. In fact, I use it in my own graduate and undergraduate courses at Bentley and Harvard University. It integrates the established body of knowledge in project management (PMBOK) with today's contemporary project management practices and the emerging body of knowledge in management of technology (MOT), all linked with the contemporary concepts of organizational behavior. The lead-in scenarios for each chapter and the questions for discussion and exercises at the end of each chapter should provide food for critical thinking in professional group discussions or academic classroom exercises. Managers and technology-oriented professionals at all levels should find this text useful in gaining an understanding of the organizational process, organizational dynamics, and critical success factors that drive technology-based project performance. Such insight can help in fine-tuning leadership style, resource allocation, and organizational developments—hence continuously improving enterprise ability to compete effectively in today's complex global markets.

The book includes the latest concepts of project management, plus my 40 years of field observations and experiences as researcher, and earlier as manager in RD&E and technology management with ITT, Westinghouse, General Electric, and GTE/Verizon, prior to my current teaching and research career at Bentley University.

I would like to express my appreciation to the many colleagues who encouraged and nurtured the development of this book. Special thanks go to the large number of project professionals, managers, and executives from the United States, South America, Europe, Asia, and Australia who contributed valuable information during various forms of professional engagement and field research, which is now part of the content and professional perspectives presented in this book.

Chapter 1

Challenges of Managing Projects in a Technology World

APPLE IPHONE 5

Photo courtesy of Apple Inc.

When Apple introduced its newest smartphone iPhone 5 at the Yerba Buena Center in San Francisco in late 2012, it was positioned for success. "iPhone 5 is the most beautiful consumer device that we've ever created," said Philip Schiller, Apple's senior vice president of Worldwide Marketing. "We've packed an amazing amount of innovation and advanced technology into a thin and light, jewel-like device with a stunning 4-inch retina display, blazing-fast A6 chip, ultrafast wireless, even longer battery life; and we think customers are going to love it."

The announcement marked the end of an 18-month product development cycle that included intricate collaboration with several software developers, dozens of component manufacturers, partners and the iPhone fabrication at Hon Hai Precision Industry (also known as Foxconn in Zhengzhou, China). Indeed, the new product is state of the art. It is the thinnest and lightest iPhone ever, completely redesigned to feature the new display screen, the world's most advanced mobile operating system, and over 200 new features such as new maps, turn-by-turn navigation, Facebook, Passbook, and more Siri® features.

However, recovering the investment for product development and rollout of the new 16 GB iPhone is not without challenges. For one thing, the cost to produce the phone is high. At over $200 per unit, Apple had to count on wireless companies to subsidize the purchasing price. Nevertheless, business analysts were optimistic that the iPhone 5 would be profitable in the long run—and as it turned out, their

optimism was not misplaced. Following up on the impressive success of the iPhone 5, in September 2013, Apple introduced the iPhone 5S and the iPhone 5C.

1.1 PROJECT MANAGEMENT IN A CHANGING WORLD: CHALLENGES AND OPPORTUNITIES

The complexities and challenges faced by Apple in developing the iPhone 5 might look modest by comparison to super projects, such as major aerospace missions, the relocation of Tata's steel plant to the Gulf of Bengal, or the organization of the next Summer Olympics. Yet, the iPhone 5 has all of the characteristics that we find in millions of technology-intensive projects. Project management has become an important variable for success in today's complex business environment, where projects span organizational lines, involving a broad spectrum of personnel, support groups, subcontractors, vendors, partners, government agencies, and customer organizations. Hence, successful execution relies on effective linkages, cooperation, and alliances among various organizational functions, critical for proper communication, and decision making. Top-down control no longer works in most of these environments, but authority must be earned and team commitment must be built as critical conditions to successful project management.

Despite its challenges, this changing environment—especially advances in computers, IT, and communication technology—creates enormous opportunities for enterprises across all industries. It is possible to execute larger, more complex projects, with leaner budgets and more predictable schedules, and to connect with a wide spectrum of resources across the world. However, technology creates its own challenges, requiring additional investment in equipment, software, infrastructure, services, and skill sets. Advances in technology have also accelerated the changes in our business environment, leading to tougher competition, lower barriers of market entry, and shorter product life cycles, requiring more agile and flexible approaches to project management. These changes have shifted the project paradigm with strong impact on business performance. This got the attention of management across all industries, many of them recognizing project management as a critical toolset for providing common language and methodology for executing multidisciplinary ventures.

1.2 GLOBAL DIMENSIONS

The changes in the global business environment have pushed these challenges to an even higher level. To succeed in our ultracompetitive, interconnected world of business, companies are continuously searching for ways to improve effectiveness. They look for partners that can perform the needed work better, cheaper and faster. Speed especially has become one of the great equalizers of competitive performance. In the case of the iPhone,

a new product may be obsolete in less than a year, unless provisions for continuous upgrading and enhancement have been built into the system and are implemented in response to evolving market needs. This results in complex project organization and execution processes, involving joint ventures, alliances, multinational sourcing and elaborate vendor relations across the globe, ranging from R&D to manufacturing, and from customer relations to field services.

Project complexity has been increasing in virtually every segment of industry and government, including computer, pharmaceutical, automotive, health care, transportation, and financial businesses, just to name a few of the most noticeable ones. New technologies, especially in computers and communications, have radically changed the workplace and transformed our global economy, focusing on effectiveness, value and speed. These technologies offer more sophisticated capabilities for cross-functional integration, resource mobility, effectiveness and market responsiveness, but they also require more sophisticated skill sets both technically and socially, dealing effectively with a broad spectrum of contemporary challenges, including managing conflict, change, risks and uncertainty.

As a result of this paradigm shift we have seen a change in the dynamics of teamwork and a change in managerial focus from efficiency to effectiveness, and from a focus on traditional performance measures, such as the quadruple constraint, to include a broader spectrum of critical success factors that support innovation, work integration, organizational collaboration, human factors, business process agility, and strategic objectives. Traditional linear work processes and top-down controls are no longer sufficient, but are gradually being replaced with alternate organizational designs, new management techniques and business processes, such as agile processes, concurrent engineering, User-Centered Design, and Stage-Gate protocols (Thamhain 2011). These techniques offer more sophisticated capabilities for cross-functional integration, resources mobility, effectiveness, and market responsiveness, but they also require more sophisticated management skills and leadership.

1.3 PROJECT DESERVE SPECIAL ATTENTION WITHIN THE ENTERPRISE

Projects are different from ongoing operations. They are one-time undertakings, such as the Apple's iPhone development, with a specific mission, purpose, and objective, usually driven by the needs and wants of a sponsor or customer, who could be an individual or an organization, internal or external to the enterprise, or both. In essence, this description identifies the components and uniqueness of projects:

> Producing specific deliverables within given time, resource and quality constraints that satisfy the project sponsor/customer.

It also identifies the boundary conditions of time, resources, quality, and customer satisfaction, referred to as *quadruple constraint*, to be discussed in the next chapter in more detail.

By their very nature projects are multidisciplinary, requiring resources and support from many organizational units. This is disruptive to the ongoing operations of the enterprise. It interferes with the mission and objectives of functional departments, and is inconsistent with established central management processes for command, control, and communications.

Thus, to minimize interference with ongoing operations, projects need to be organized and managed separately from the ongoing operations, yet well integrated with the enterprise. With the emergence of contemporary project management, virtually every enterprise with project-related activities established its own project management system with various degrees of formality and sophistication. The aim is to have a common infrastructure with methodologies, supportive processes, tools, and measurement systems that ensures consistent project delivery across the enterprise. Communication is at the heart of any of these management systems for effectively connecting among all team members, including partners, support organizations and other internal and external stakeholder communities.

As it has evolved over the past 60 years, modern project management provides the type of disciplined yet flexible framework for effectively planning, organizing, and executing projects. It has its own body of knowledge, providing a common language and methodology with tools and techniques for managing multidisciplinary ventures, regardless of their size, shape, or industry.

1.4 THE UNIQUE NATURE OF TECHNOLOGY PROJECTS

Technology-intensive projects have their unique characteristics and challenges. By definition, these projects have to deal with *technology*, a fast-changing knowledge area associated with risk and uncertainty. The problems to be solved are often complex and solutions untried, requiring experimental, iterative approaches, innovation and creativity, and highly specialized skill sets. Although one could make an argument that these issues also exist in many low-technology projects, they are amplified as dependence on technology intensifies, such as we see in the iPhone example. Therefore, it is not surprising that managers of technology-based projects see their work environment as different, requiring unique organizational structures, policies, interaction among people, and support systems. Yet the classification of projects along technology lines is not easy. Let's first look into the unique characteristics of technology-intensive projects before suggesting a specific classification based on degree of technology and complexity.

WHAT IS DIFFERENT ABOUT TECHNOLOGY-INTENSIVE PROJECTS?

In our highly connected world, most project managers must deal with technology. They must function in a business environment that uses technology for competitive advantage, and their projects are heavily steeped in technology. Virtually every segment of industry and government tries to leverage technology to improve effectiveness, value, and speed. Traditional linear work processes and top-down controls are no longer sufficient, but are gradually being replaced by alternate organizational designs and new, more agile management techniques and business processes, such as concurrent engineering, design-build, stage-gate and user-centered design. These techniques offer more sophisticated capabilities for cross-functional integration, resources mobility, effectiveness, and market responsiveness, but they also require more sophisticated skills to effectively deal with a broad spectrum of contemporary challenges, both technically and socially, including higher levels of conflict, change, risks, and uncertainty, and a shifting attention from functional efficiency to process integration effectiveness, emphasizing organizational interfaces, human factors, and the overall business process. Taken together, technology-intensive projects can be characterized as follows:

- Value creation by applying technology
- Strong need for innovation and creativity
- High task complexities, risks, and uncertainties
- Resource constraints and tight end-date-driven schedules despite tough performance requirements
- Highly educated and skilled personnel, broad skill spectrum
- Specific technical job knowledge and it competency
- Need for sophisticated people skills, ability to work across different organizational cultures and values, and to deal with organizational conflict, power, and politics
- Complex project organizations and cross-functional linkages
- Complex business processes and stakeholder communities
- Technology used as a tool for managing projects
- Replacement of labor with technology
- Advanced infrastructure
- High front-end expenditures early in the project life cycle
- Low short-term profitability in spite of large capital investment
- Fast-changing markets, technology, regulations
- Intense global competition, open markets, and low barriers to entry
- Short product life cycles affect time to market
- Need for quick market response
- Complex decision-making processes
- Many alliances, joint ventures, and partnerships

1.4.1 Characteristics of Technology-Intensive Projects

Although technology and management practices vary considerably among companies, specific characteristics can be defined to describe technology-intensive projects as part of their dynamic environment and organizational interaction as summarized in 16 categories:

1. **Value creation by applying technology.** Technology-based projects create value primarily by leveraging technology. They exploit or commercialize technology. Examples range from plastics and fiber optics to financial services and e-commerce. The technology-based enterprise competes through technological innovation. Project management provides the process, fueled by technology, for creating new and unique products, services, systems, equipment, or advanced materials. This added value is part of the innovation process, where the final product, such as the Internet service or computer chip, is worth a lot more than its ingredients. Hence, "Innovation is the key driver to competitiveness . . . and long-term economic growth" (US Department of Commerce 2012).
2. **High task complexity, risks, and uncertainty.** Given their technical complexity, market uncertainties, changing technologies, and regulatory ambiguities, technology-based projects can be very risky in terms of economics and technical success. Because of these uncertainties, technology-intensive projects utilize unique organizational structures, work processes, decision-making tools, and leadership styles.
3. **Resource constraints and tight end-date driven schedules despite tough performance requirements.** Because of time-to-market pressures and intense competition typical for technology-based projects, resources and schedules are often very tight despite complex requirements and uncertainties, all adding to the challenges of project managers.
4. **Highly educated and skilled personnel.** Technology-intensive projects require special knowledge, skill sets, and competencies to do the technical work. They also require sophisticated people skills, the ability to deal with organizational conflict, power, and politics, and the ability to work effectively in teams across functional lines toward project integration.
5. **Complex project organizations and cross-functional linkages.** Because of the need to integrate among many disciplines, contractors, and partners, as well as the intricate work processes that often span wide geographic areas, high-tech projects are rarely organized according to conventional structures, such as the matrix or projectized organization. Instead, they are arranged as "studios" where team members organize themselves around tasks, determining their responsibilities, work interfaces, and deliverables, sharing accountability and decision-making among the task owners and their interfaces. The evolving project organizations are usually hybrids of conventional structures

capable of working within established project execution templates, such as stage gate, concurrent, spiral, or agile/scrum, and interfacing with complex business processes and stakeholder communities.

6. **Technology used as a tool for managing projects.** High-tech projects use technology extensively in support of their projects execution. This includes sophisticated communication and reporting systems, computer simulation and modeling, advanced testing, and the latest software for project planning, tracking, and control. Often, these project-specific technologies are integrated with other enterprisewide management systems such as SAP or Oracle to gain operational advantages that lead to more predictable, cost-effective, faster, and market-focused project implementation.
7. **Replacement of labor with technology.** Technology-intensive projects are often part of a technology enterprise, such as computers, automotive, or pharmaceutical, that utilizes a wide spectrum of technology with the objective to gain economic benefits, speed, better quality, and reliability. The added value requires additional resources in the form of more advanced equipment, infrastructure, and software, but reduces labor, explaining the fact that technology-intensive projects and their host companies are mostly *capital* (rather than labor).
8. **Advanced infrastructure.** Technology-intensive projects utilize special state-of-the-art equipment, facilities, infrastructure, software tools, and training in support of the project work to be performed.
9. **High front-end expenditures early in the project life cycle.** The effort and resources needed at the front-end project work, such as planning, feasibility assessment, and R&D, seem to increase with the degree of technology used. For example, expenditures for planning and feasibility assessment of high-tech projects run typically above 10 percent of the total budget, double the average across all projects.
10. **Low short-term profitability in spite of large capital investment.** Technology-intensive projects often need large amounts of cash for capital equipment for reasons just discussed, sometimes more than they can generate. They are the classical "stars" in BCG's Growth-Share Matrix (Grant 2010). As a result, strong financial leveraging and low profitability are quite common, in addition to joint ventures, partnerships, and extensive outsourcing, even for well-established high-tech giants, such as Amazon, Boeing, Intel, Microsoft, Pfizer, and Seagate.
11. **Changing markets, technology, and regulations.** Technology-based projects are likely to operate in continuously changing business environments with fast-changing markets and technologies, low barriers to entry, and high exposure to liabilities and regulations.
12. **Intense global competition, open markets, low barriers to entry.** Traditional barriers to entry, such as infrastructure, brand loyalty, and established supply chains, are virtually nonexistent for high-tech businesses. In particular "new and emerging technologies" can reset the competitive field to "ground zero," whipping out any competitive advantage of established products and services (Andrew and Sirkin 2003).

This reality strongly influences the way projects are organized and managed, leading to more empowerment and autonomy at the project team level to promote the agility and speed needed for optimizing the project value under time-to-market pressure and changing conditions.

13. **Short product life cycles.** Driven largely by changing market conditions, emerging technologies and strong competition, life cycles of technology-based product are shorter, putting pressure on time to market as a critical project performance measure.
14. **Need for quick market response.** High-tech companies are fast, agile, and flexible in responding to business opportunities and threats. This also reflects in their project organizations and management style, empowering teams and relying on more autonomous work processes that enable quick reaction to changing conditions.
15. **Complex decision-making processes.** As a result of high risks, great uncertainties, and the dynamics that technology-intensive projects are exposed to, top-down or centralized management is usually ineffective. To a large extend, it is being replaced by *distributed* (or *team-based*) *decision making*, which promotes risk sharing, collaboration, and commitment at the project team level.
16. **Many alliances, joint ventures, and partnerships.** Because of the potentially high costs, risks, and complexities of high-tech project, virtually no company has the resources to handle all the facets of a technology development, its rollout and field support single-handed. Resource pooling, from cooperative agreements to joint ventures, partnerships and acquisitions are quite common among high-tech projects to raise the resources for implementing the new venture in a timely fashion.

To summarize the areas that are unique and different in managing technology-intensive projects, let us focus on six selected business subsystems, as graphically shown in Figure 1.1 and discussed next.

Figure 1.1 Business subsystems unique to technology-intensive project management

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